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AGRA UNIVERSITY JOURNAL OF RESEARCH

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Chief Editor

AGRA UNIVERSITY
JOURNAL OF RESEARCH

Vol. VII, Part 1 *SCIENCE* **January 1958**

SEASONAL MATERIAL FOR A FLORA OF NAINI TAL

By K. S. BHARGAVA, D. PHIL., PH. D. and R. K. GUPTA, M. SC.,
D. S. B. GOVERNMENT COLLEGE, NAINITAL.

INTRODUCTION

This study of the flora of Naini Tal was undertaken with two objectives in mind. The first was to compile as complete as possible a list of the flowering plants that occur in this region during different parts of the year so that visiting botanists may have ready at hand the material available to them and they may know what to find at a particular period. The second objective was to study the individual plant in the environment in which it grows, and to prepare an illustrated flora of the region and to find out the varieties of medicinal plants available.

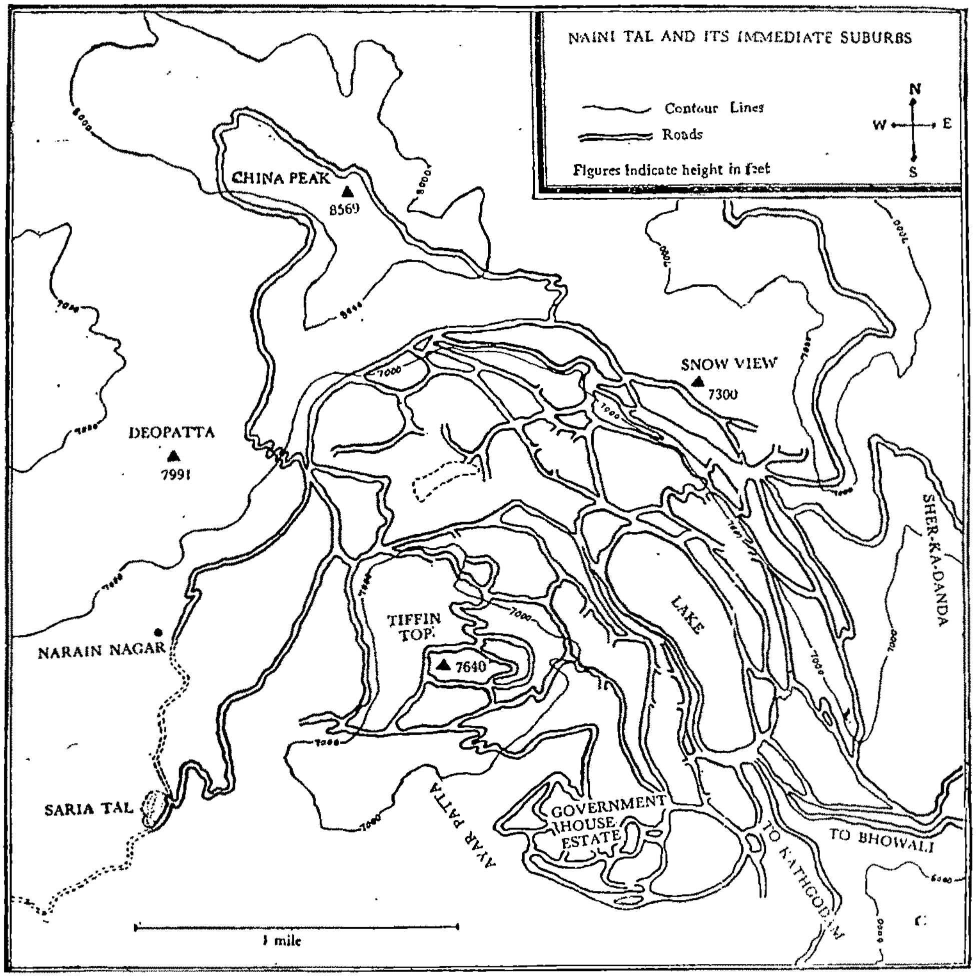
Earlier collectors who have visited the locality include Davidson, Duthie, Jacquemont, Osmaston, Royle, Strachey, Thompson, Winterbottom and Wallich. The results of Strachey have been compiled in a catalogue of plants of Kumaon which was published in 1906 while Osmaston (1927) compiled a forest flora of Kumaon giving mainly the trees and shrubs. He does not include the herbaceous vegetation. Recently Jain (1956) has given a list of plants collected by him in May and June 1954.

Earliest noteworthy collection of this area labelled as coming from Nainital is to be found in the Forest Research Institute Herbarium at Dehra Dun, made by Davidson in 1879. Other collections include those by UrtiDutt 1913, Bis Ram 1933, S. D. Joshi 1914, Hirasingh and H. G. Champion 1937. The last named collector in a personal communication to the senior author emphasised the need of such a flora and pointed out that he had made an extensive collection in Nainital except in monsoon period.

The present paper gives the names of plants flowering in different months of the year. It is hoped to publish an illustrated flora of the locality in near future. The writers are very grateful to Sri M. B. Raizada, Botanist, Forest Research Institute, Dehra Dun, for his kind help and permission to consult the herbarium, to Dr. H. G. Champion, School of Forestry, Oxford, for placing a card index prepared by him at the disposal of the senior author, and to Rev. Fr. H. Santapau, Director, Biological Section, St. Xavier's College, Bombay, for his kind help in publication of this work.

Location and Topography

Naini Tal is situated 29° 24° North Latitude and 79° 28° East longitude in a valley of Gagar range running east and west bounded on the north by peak of China (8, 569 ft.) continued by Alma peak and the Sher-ka-



danda to the eastern extremity, where the ridge descends almost to the level of the lake. On the west the rugged hill of Deopatta rises to a height of 7,991 ft. diminishing gradually towards east. Eastern boundary is a pass through which the surplus waters of the lake find an exit. Map. 1.

Eastern end is occupied by the lake giving the name Naini Tal to the place. The surface of the lake has an elevation of 6,350 ft. Its length, breadth and depth is 1,567 yds., 506 yds. and 31 yds. respectively. There is a sulphur spring in the lake itself and also one outside near Tallital bazar near its exit.

CLIMATE

The climate on the whole is temperate. The temperature rises upto 90° F. in summer while in the coldest part of the winter it has an average of about 32° F., though temperatures as low as 26° F. have been recorded. The bright sun in the winter months renders the cold little felt.

The average rainfall is about 110″, being heaviest in the months of June to September. The rainy season lasts from about the middle of June to the end of September. From beginning of October to middle of December it is usually dry, although occasional showers are not uncommon. From December till March the weather is often unsettled when strong winds, snowfalls and winter showers are the usual features. Because of its shut-in-position and dampness resulting from heavy rainfall, Naini Tal is colder than the rest of the hill tracts. The snow does not lie long on the ground except in shady situations. In April, May and early part of June the mercury shoots up to its maximum and the weather is dry but one may expect showers and thunderstorms during this period also.

GEOLOGY

The rocks comprise a set of shales and black or dark slates with bands of fine quartzites capped with massive dark blue grey limestone of dolomite. The steep slopes of the limestone capped slate hills have caused landslips of considerable size from time to time. The slates are much broken and vary in colour from shades of purple to grey and green. The Ayarpatta slope consists mainly of massive limestone with the exception of the lower slopes on the west, while the lower slopes of China consist of screes derived from the slates of limestone above. No fossils have been found in any of these rocks, but they are probably very ancient.

The soil varies considerably. It is from light loam to clayey loam formed from the limestone. On steep slopes it is shallow and poor and is largely mixed with fragmented rocks, while on gentler slopes and in valleys it is usually fresh, deep and fertile.

VEGETATION

There is an appreciable variation in the floristic composition. On the southern aspect, except on steep shaly slopes where the soil is usually bare, the commonest type is grassland with or without scattered trees or shrubs. These grassy slopes are rich in herbs of many kinds most of which flower during the rains. In fact the herbs and grasses mostly die down from October to May, thus giving rise to brown colouration.

Forests of *Quercus incana* and *Q. floribunda* are most common in moister north and north western aspects. *Cupressus torulosa* also occurs in compact area below China peak and southern slopes of Land's End. On southern slopes of Ayarpatta ridge miscellaneous scrub forests with scattered tree growth also occur. Regeneration of these types is very scanty and unsatisfactory, in some cases regeneration of some important species being totally absent. Damage by lopping and grazing is common. Goats and sheep belonging to butchers and mules used for carriage of *bajri* cause the most severe damage. Cattle belonging to villagers and other inhabitants are responsible for damage by browsing and grazing. Quarrying of stones for the construction of buildings and digging hillsides for spreading earth on roads in the station area are fairly common and are responsible for increased erosion. Damage done by fires, storms and snow does not assume serious proportions.

ANNOTATED LIST

The families are listed alphabetically and so are the genera and species within a family. Wherever possible the botanical name is followed by a common name, given in brackets, habit of the plant and colour of the flower. Every effort has been made to adjust the nomenclature of the plants according to latest findings on the subject. The reference numbers given after the specimen refer to herbarium sheets preserved in the herbarium of D.S.B. Government College, Nainital.

Plants flowering in the month of January

	COMPOSITAE		
Galinsoga parviflora Cav.	Herb	White yellow	1, 292.
	CONIFERAE		
Cupressus torulosa Don. (Surai)	Tree	Green	
	LORANTHACEAE		
Loranthus vestitus Wall. (Bana)	Para. shrub	Green	
	PRIMULACEAE		
Primula floribunda Wall.	Herb	Yellow.	
	THYMELAEACEAE		
Daphne papyracea Decne (Satpura)	Shrub	White purple.	
	URTICACEAE		
Parietaria debilis Forst.	Herb	Green	

Plants flowering in the month of February

	ACANTHACEAE		
Dicliptera bupleuroides Nees.	Herb.	Violet	155, 280.
	BERBERIDACEAE		
Berberis asiatica Roxb. (Kilmora))	Shrub	Yellow	
	CARYOPHYLLACEAE		
Cerastium vulgatum Linn.	Herb.	White	322.
	COMPOSITAE		
Galinsoga parviflora Cav.	Herb.	White yellow	
Taraxacum officinale Wigg.	Herb	Yellow	301
	CONIFERAE		
Cupressus torulosa Don.	Tree	Green	
Pinus Roxburghiana Sarg. (Chir) *syn. Pinus longifolia* Roxb.	Tree	Green	
	CRUCIFERAE		
Cardamine impatiens Linn.	Herb	White	282
	JUGLANDACEAE		
Juglans regia Linn. (Akhrot)	Tree	Green	
	ROSACEAE		
Rubus lasiocarpus Smith. (Kala-Hinsalu)	Shrub	Pink	359
	SALICACEAE		
Populus ciliata Wall. (Garhpipal)	Tree	Green	
	SAPINDACEAE		
Acer oblongum Wall. (Putli, Kirmoli)	Tree	White green	387
	SAXIFRAGACEAE		
Bergeria ligulata Engel. (Silphurwa) Syn. *Saxifraga ligulata* Wall. *Saxifraga ciliata* Royle.	Herb.	Pinkpurple	316
	THYMELAEACEAE		
Daphne papyracea Decne. (Saptura, Barwa) syn. *Daphne cannabina* Wall.	Shrub	Liliac white	262
	VIOLACEAE		
Viola canescens Wall. (Banefsha)	Herb	Liliac	293

Plants Flowering in the month of March

	ACANTHACEAE		
Dicliptera bupleuroides Nees.	Herb	Violet	

ANACARDIACEAE			
Rhus Cotinus Linn. (Chariat, Chariant)	Tree	Purple	
APOCYNACEAE			
Vinca major	Herb	Liliac	230
BERBERIDACEAE			
Berberis asiatica Roxb. (Kilmora)	Shrub	Yellow	
CAMPANULACEAE			
Campanula colorata Wall.	Herb	Pale liliac	301
Lobelia pyramidalis Wall.	Herb	Pink	
CAPRIFOLIACEAE			
Viburnum cotinifolium Don. (Gwia)	Shrub	Pink	321
Lonicera quinquelocularis Hardw. (Bhanti, Badru)	Shrub	Yellow	
CELASTRACEAE			
Euonymus echinatus Wall. (Pinna)	Tree	White	295
COMPOSITAE			
Ainsliaea pteropoda D.C.	Herb	White Pink	97
Crepis japonica Benth.	Herb	Pale yellow	283, 361
Galinsoga parviflora Cav.	Herb	White yellow	
Taraxacum officinale Wigg.	Herb	Yellow	
CONIFERAE			
Pinus Roxburghiana Sarg. (Chir)	Tree	Green	
CONVOLVULACEAE			
Evolvulus alsinoides Linn.	Herb	Blue	
CORIARACEAE			
Coriaria nepalensis Wall. (Makroli, Makol)	Shrub	Green	
CRASSULACEAE			
Sedum rosulatum Edgew.	Herb	White	300
CRUCIFERAE			
Cardamine impatiens Linn.	Herb	White	
CUPULIFERAE			
Carpinus faginea Lindl. (Katiu, Pomni)	Tree		
Carpinus viminea Wall. (Pomni, Khatin, Kath Kharik)	Tree		
ERICACEAE			
Rhododendron arboreum Smith. (Buruns)	Tree	Red	320

EUPHORBIACEAE

Buxus sempervirens Linn. (Papri) var. *macrophylla*	Tree	Yellow green	
Euphorbia Maddeni Boiss.	Herb.	Green yellow	

GERANIACEAE

Geranium lucidum Linn.	Herb	Pink	275
Geranium ocellatum Camb.	Herb	Pink	318
Oxalis corniculata Linn. (Tipatia. Amelda)	Herb	Yellow	205 309

HYPERICACEAE

Hypericum cernuum Roxb. (Piunli)	Shrub	Yellow	308

JUGLANDACEAE

Juglans regia Linn. (Akhrot)	Tree	Green	
Engelhardtia Colebrookiana Lindl. (Gadh-mohwa, Garmalu)	Tree	Green	

LABIATAE

Ajuga parviflora Wall.	Herb	Liliac	
Micromeria biflora Benth.	Herb	Pink	220
Plectranthus rugosus Wall. (Kurkha)	Herb	White	143, 258.
Scutellaria angulosa Benth.	Herb	White purple	305

LAURACEAE

Litsaea consimilis Nees (Bailara, Chirara, Muira)	Shrub	Pale yellow	

LEGUMINOSAE

Indigofera Gerardiana Wall. (Sakina) var. *heterantha*	Shrub	Purple	95, 306.

LORANTHACEAE

Viscum album Linn. (Chulu-ka-banda)	Shrub parasitic.	Green	

OLEACEAE

Jasminum humile Linn. (Pili chameli)	Shrub	Yellow	353
Olea glandulifera Wall. (Garura, Gair)	Tree	White	

ONAGRACEAE

Oenothera rosea Sol.	Herb	Pink	5,185

POLYGONACEAE

Polygonum alatum Buch.-Ham.			
var. *parviflora*	Herb	White pink	
var. *Metziana*	Herb	Pink	
Polygonum chinense Linn.(Ameta)	Shrub	White pink	

PRIMULACEAE

Primula denticulata Smith.	Herb	Pale Liliac	
Primula floribunda Wall.	Herb	Yellow	

RANUNCULACEAE			
Clematis montana BuchHam (Kanguli, Jai) var. *major.*	Climber	White	312
Ranunculus arvensis Linn.	Herb	Yellow	
RHAMNACEAE			
Rhamnus purpureus Edgew. (Chedul)	Shrub	Green	
ROSACEAE			
Fragaria indica Andr. (Bhiula, Kiphalia)	Herb	Yellow	
Potentilla Kleiniana Wight. and Arn.	Herb	Yellow	92
Rubus ellipticus Smith (Hinsalu)	Shrub	White	2
Rubus lasiocarpus Smith (Kala Hinsalu)	Shrub	Pink	359
SALICACEAE			
Populus ciliata Wall. (Garh Pipal, Syan)	Tree	Green	
Salix babylonica Linn. (Bedmajnu)	Tree	Green	
Salix elegans Wall. (Bogchia)	Tree	Green	74, 106
SAPINDACEAE			
Acer caudatum Wall. (Rath Kanchula, Kamia) syn. *Acer acuminatum*	Tree	White green	366
Acer oblongum Wall. (Kirmoli, Putli)	Tree	White green	367
Acer pictum Thunb. (Kainju, Gadhpapri)	Tree	Green yellow	
Acer villosum Wall. (Mandra,)	Tree	White green	
SAXIFRAGACEAE			
Bergeria ligulata Engel. (Silphurwa)	Herb	Pink purple	
Deutzia staminea R. Brown (Gugti, Dhaniala)	Shrub	White	294
SCROPHULARIACEAE			
Veronica agrestis Linn.	Herb	Blue	367
Veronica biloba Linn.	Herb	Blue	
THYMELAEACEAE			
Daphne papyracea Wall. (Barwa, Satpura)	Shrub	White liliac	
URTICACEAE			
Debregeasia hypoleuca Wedd. (Tushiara, Tussara)	Shrub	Green	
Parietaria debilis Forst	Herb	Green	
Ulmus Wallichiana Planch. (Mairu, Chamarmowa)	Tree	Green	
VALERIANACEAE			
Valeriana Wallichii DC. (Semwa)	Herb	White pink	311
VIOLACEAE			
Viola canescens Wall.	Herb	Liliac	293

Plants flowering in the month of April.

	ACANTHACEAE		
Dicliptera bupleuroides Nees.	Herb	Pink	
	APOCYNACEAE		
Trachelospermum fragrans Hook	Shrub Sc.	White	
Vinca major	Herb	Pink	
	BERBERIDACEAE		
Berberis asiatica Roxb. (Kilmora)	Shrub	Yellow	
Berberis edgeworthiana (Kameti)	Shrub	Yellow	10
Berberis Lycium Royle (Kilmora)	Shrub	Yellow	
Holboellia latifolia Wall.			
Var. angustifolia. (Ramkepa)	Shrub Sc.	Purple	
	CAMPANULACEAE		
Campanula colorata Wall.	Herb	Pale liliac	
	CAPRIFOLIACEAE		
Lonicera quinquelocularis Hardw. (Bhanti)	Shrub	Yellow	
Viburnum continifolium Don. (Gwia)	Shrub	Pink	
Viburnum stellulatum Wall. (Maleo)	Shrub	White	321
	CARYOPHYLLACEAE		
Cerastium vulgatum Linn.	Herb	Yellow white	
Stellaria bulbosa Wulf.	Herb	White	
Stellaria latifolia Benth.	Herb	White	
	CELASTRACEAE		
Euonymus echinatus Wall.	Tree	White	
Euonymus tingens Wall. (Kon-Kon)	Tree	Yellow white	
	COMPOSITAE		
Ainsliaea pteropoda DC.	Herb	White pink	
Aster molliusculus Wall.	Herb	Liliac	98
Carduus nutans Linn.	Herb	Red	
Crepis japonica Benth.	Herb	Pale yellow	
Erigeron multicaulis Wall.	Herb.	Purple	297, 186
syn. Erigeron alpinus			
Erigeron multiradiatus Benth.	Herb	Purple	187
Galinsoga parviflora Cav.	Herb	White yellow	
Gerbera gossypiana Royle. (Kapase)	Herb		
Taraxacum officinale Wigg. var. *eriopoda*	Herb	Yellow	
	Coniferae		
Abies pindrow Spach.	Tree	Green	
Picea smithiana Boiss.	Tree	Green	
syn. *Picea morinda* Linn. (Kala Chillu)			
Pinus roxburghii Sarg	Tree	Green	

CORIARIACEAE			
Coriaria nepalensis Wall. (Makroli, Makol)	Shrub	Green	
CRASSULACEAE			
Sedum adenotrichum Wall.	Herb	Pink	299
Sedum rosulatum Edgew.	Herb	White	
CRUCIFERAE			
Arabis alpina Linn.	Herb	White	
Capsella Bursa-pastoris Medic.	Herb	White	
Cardamine impatiens Linn.	Herb	White	
Lepidium sativum Linn. (Halang)	Herb	White	374
Nasturtium montanum Wall.	Herb	White	
Nasturtium officinale R. Br. (Pania)	Herb	White	
Sisymbrium wallichii Hook. f. & Thomas	Herb	White	
CUPULIFERAE			
Betula alnoides Buch-Ham. (Saur, Chamar pyan)	Tree	Green	
Quercus floribunda Wall. (Moru) syn. *Quercus dilatata* Lindl.	Tree	Green	336
Quercus incana Roxb. (Banj, Ban)	Tree	Green	296
DIPSACACEAE			
Morina persica Linn.	Shrub	Pink	363
ELAEAGNACEAE			
Elaeagnus umbellata Thunb. (Geowain, Giwai)	Shrub	Yellow	
ERICACEAE			
Rhododendron arboreum Smith. (Buruns)	Tree	Red	
EUPHORBIACEAE			
Buxus sempervirens Linn. (Papri)	Tree	Yellow green	
Sarcococca pruniformis Lindl. (Paliala, Geru) var. *Hookeriana*	Shrub	Pale yellow	
FUMARIACEAE			
Corydalis rutaefolia Sibth	Herb	Purple	
GENTIANACEAE			
Gentiana argentea Royle	Herb	Blue	
GERANIACEAE			
Geranium lucidum Linn.	Herb	Pink	
Geranium ocellatum Camb.	Herb	Pink	
Oxalis corniculata Linn. (Amelda, Tipatia)	Herb	Yellow	

HYPERICACEAE

Hypericum cernuum Roxb. (Piunli)	Shrub	Yellow	
Hypericum lysimachoides Wall·	Shrub	Yellow	16
Hypericum perforatum Linn.	Shrub.	Yellow	

ILAICAEAE (AQUIFOLIACEAE)

Ilex dipyrena Wall. (Kandir, Kandela)	Shrub	White	449

IRIDACEAE

Iris Kumaonensis Wall.	Herb	Liliac	
Iris nepalensis Don.	Herb	Liliac	

JUGLANDACEAE

Juglans regia Linn. (Akhrot)	Tree	Green	
Engelhardtia colebrookiana Lindl. (Garmalu)	Tree	Green	

LEGUMINOSAE

Albizzia julibrissin Durazzini syn.			
Albizzia mollis Boiv. (Kaunera, Sirsa)	Tree	Pink	365
Astragalus trichocarpus Grah.	Shrub	Pale liliac	
Indigofera cylindracea (Sakina) var. *albo* Raizada	Shrub	Purple	
Indigofera Gerardiana var. heterantha Wall.	Shrub	Purple	
Lathyrus aphaca Linn. (Jangli matar)	Herb	Yellow	
Parochetus communis Buch-Ham	Herb	Violet blue	
Trifolium pratense Linn.	Herb	Purple	213
Trifolium repens Linn.	Herb	White	334
Vicia tenera Grah.	Herb	Pale pink	

LABIATAE

Ajuga bracteosa Wall.	Herb	Liliac	
Lamium album Linn.	Herb	White pink	
Micromeria biflora Benth.	Herb	Pink	
Nepeta distans Benth.	Herb	Pale pink	
Plectranthus rugosus Wall. (Kurkha)	Herb	White	
Salvia lanata Roxb.	Herb	Blue grey	
Scutellaria angulosa Benth	Herb	White purple	305

LAURACEAE

Litsea consimilis Nees. (Chirara, Bailara)	Shrub	Pale yellow	

LILIACEAE

Polygonatum verticillatum Allioni	Herb	White green	
Smilax parvifolia Wall. (Kukandra)	Climbing Shrub	Purple	30

MYRSINACEAE

Myrsine africana Linn. (Ghani)	Shrub	Red	
Myrsine semiserrata Wall.	Shrub	White	

OLEACEAE

Fraxinus floribunda Wall. (Angu, Angar)	Tree	White	
Jasminum grandiflorum Linn. (Chameli, Jai)	Shrub	White purple	

Jasminum humile Linn. (Pilichameli)	Shrub	Yellow	354
Jasminum officinale Linn. (Jai)	Shrub	White	

ONAGRACEAE

Oenothera rosea Sol.	Herb	Pink	

POLYGALACEAE

Polygala crotalarioides Buch-Ham	Herb	Purple	141

POLYGONACEAE

Fagopyrum esculentum Moench. (Ogal)	Herb	White	14
Polygonum alatum Buch-Ham.	Herb.	White	67
Rumex hastatus Don. (Almora)	Herb	Green	102
Rumex nepalensis Spreng.	Herb	Green	

PRIMULACEAE

Androsace lanuginosa Wall.	Herb.	Purple	

RANUNCULACEAE

Clematis montana Buch-Ham (Kanguli) var. major	Climber	White	
Delphinium denudatum Wall.	Herb.	Blue	314
Ranunculus arvensis Linn.	Herb	Yellow	
Thalictrum pedunculatum Edgew. (Mamiri)	Herb	White	

RHAMNACEAE

Rhamnus purpureus Edgew.	Shrub	Green	
Rhamnus virgatus Roxb. (Chedul)	Shrub	Green	

ROSACEAE

Cotoneaster bacillaris Wall. (Ruins)	Shrub	White	
Cotoneaster microphylla Wall. (Gheri) var. *buxifolia.*	Shrub	White	21
Fragaria indica Andr. (! hiula, Kiphalia)	Herb	Yellow	316
Fragaria vesca Linn.	Herb	White	215
Potentilla Kleiniana Wight. & Arn.	Herb	Yellow	
Potentilla nepalensis Hook. f.	Herb	Red	13, 10.
Prinsepia utilis Royle. (Bhekal)	Shrub	White	
Rosa macrophylla Lindl. (Kunja)	Shrub	White Pink	
Rosa moschata Mill. (Kunja)	Climbing shrub	white	90
Rubus ellipticus Smith. (Hinsalu)	Shrub	White	
Rubus lasiocarpus Smith (Kalahansalu)	Shrub	Pink	
Rubus paniculatus Smith. (Kaithula)	Shrub	White	
Spiraea canescens Don. (Mairala, Mairab.)	Shrub	White	11, 117

RUBIACEAE

Randia tetrasperma Roxb. (Gharri, Ghara)	Herb	White green	

SALICACEAE

Populus ciliata Wall. (Syan, Gadhpipal)	Tree	Green	
Salix babylonica Linn. (Bedmajnu)	Tree	Green	
Salix daphnoides Linn. (Bashroi)	Tree	Green	
Salix elegans Wall. (Bogchia)	Tree	Green	

SAPINDACEAE

Acer caudatum Wall.	Tree	White green	
Acer oblongum Wall.	Tree	White green	
Acer pictum Thunb (Gadhpapri, Kainju)	Tree	White green	
Acer villosum Wall. (Mandra,)	Tree	White green	
Aesculus indica Colebr. (Pangar)	Tree	White yellow	33
Staphylea Emodi Wall. (Sablata, Karis)	Tree	White yellow	

SAXIFRAGACEAE

Bergeria ligulata Engl. (Silpharwa) syn. *Saxifraga ligulata* Royle.	Herb	Pink purple	
Deutzia staminea R. Brown (Gugti, Dhaniala)	Shrub	White	294

SCROPHULARIACEAE

Lindenbergia grandiflora Benth.	Herb	Yellow	257
Veronica anagallis Linn.	Herb	Pale purple	
Veronica agrestis Linn.	Herb	Blue	
Veronica biloba Linn.	Herb	Blue	

THYMELAEACEAE

Daphne papyracea Wall. (Satpura)	Shrub	White liliac

URTICACEAE

Debregeasia hypoleuca Wedd. (Tushiara, Syanru)	Shrub	Green
Parietaria debilis Forst.	Herb	Green

VALERIANACEAE

Valeriana wallichii D.C. (Semwa)	Herb	White pink

VIOLACEAE

Viola canescens Wall. (Banefsha)	Herb	Liliac

Plant flowering in the month of May

ACANTHACEAE

Dicliptera bupleuroides Nees.	Herb	Pink	
Strobilanthes Dalhousianus C.B. Clark (Patheura)	Shrub	Blue	261

AMARANTACEAE

Achyranthes aspera var. *phorphyris-tachya* Linn.	Shrub	Green purple,	393
Achyranthes bidentata Blume (Chirchita)	Shrub	Green purple	
Amaranthus paniculatus Linn. (Bathua)	Herb	Red	
Celosia argentea Linn. (Sufed-murg ka-phul)	Herb	White	

APOCYNACEAE

Vinca major	Herb	Liliac

ASCLEPIDIACEAE

Marsdenia Roylei Wight. (Murkhila, Marvabel)	Shrub	Orange	103

BERBERIDACEAE

Berberis aristata var. *floribunda* D.C. (Kilmora)	Shrub	yellow	
Berberis chitria Ham. (Chotra, Chetai)	Shrub	Yellow	

CAMPANULACEAE

Campanula colorata Wall.	Herb	Pale liliac	

CAPRIFOLIACEAE

Abelia triflora R.Br. (Bedra)	Shrub	Pale pink	
Lonicera quinquelocularis Hardw. (Bhanti)	Shrub	Yellow	
Virburnum continifolium Don. (Gwia)	Shrub	Pink	
Viburnum stellulatum Wall. (Maleo)	Shrub	White	

CARYOPHYLLACEAE

Cerastium vulgatum Linn.	Herb	White	
Gypsophila cerastoides D. Don	Herb	White	83
Stellaria bulbosa Wulf.	Herb	White	
Stellaria latifolia Benth.	Herb	White	
Stellaria longissima Wall.	Herb	White	371

CELASTRACEAE

Euonymus pendulus Wall. (Kath Konkon)	Tree	White yellow	
Euonymus tingens Wall. (Kon-Kon)	Tree	White	

CHENOPODIACEAE

Chenopodium album Linn. (Bethwa)	Herb	Green	43

COMPOSITAE

Aster molliusculus Wall.	Herb	Liliac	
Carduus nutans Linn.	Herb	Red	
Crepis japonica Benth.	Herb	Pale yellow	
Erigeron multicaulis var. *obovatus* D.C.	Herb	Pale purple	
Erigeron multiradiatus Benth.	Herb	Purple	
Galinsoga parviflora Cav.	Herb	White yellow	
Gerbera gossypiana Royle (Kapas)	Herb	Pink	
Serratula pallida DC.	Herb	Purple	3
Taraxacum officinale Wigg. (Dudhli)	Herb	Yellow	
Tragopogon gracilis Don.	Herb	Yellow	362

CORNACEAE

Cornus macrophylla Wall. (Khagasa, Kais)	Tree	White	

CRASSULACEAE

Sedum adenotrichum Wall.	Herb	Pink purple	
Sedum rosulatum Edgew	Herb	White	

CRUCIFERAE

Capsella Bursa-pastoris Medic.	Herb	White
Lepidium sativum Linn. (Halang)	Herb	White
Nasturtium montanum Wall.	Herb	Yellow
Nasturtium officinale R.Br. (Pania)	Herb	White

CUPULIFERAE

Betula alnoides Buch-Ham. (Saur)	Tree	Green
Quercus floribunda Wall. (Moru) syn. *Quercus dilatata* Lindl.	Tree	Green
Quercus incana Roxb. (Ban, Banj)	Tree	Green

DIPSACACEAE

Morina persica Linn.	Shrub	White pink

DIOSCORIACEAE

Dioscorea deltoidea Wall. (Gethi)	Climber	White

ELAEAGNACEAE

Elaeagnus umbellata Thunb. (Geowain)	Shrub	White

ERICACEAE

Pieris ovalifolia D.Don. (Ayar)	Tree	White	79
Rhododendron arboreum (Buruns)	Tree	Red	

EUPHORBIACEAE

Buxus sempervirens Linn. (Papri) var. *microphylla*	Tree	Yellow green
Sarcococca pruniformis Lindl. (Paliala, Geru) var. *Hookeriana*	Shrub.	Pale yellow

GENTIANACEAE

Gentiana argentea Royle	Herb	Blue
Gentiana pedicillata	Herb	Blue

GERANIACEAE

Geranium lucidum Linn.	Herb	Pink	
Geranium nepalense Sweet	Herb	Pale Pirple	350
Geranium ocellatum Camb.	Herb	Pink	
Oxalis corniculata Linn. (Amelda)	Herb	Yellow	

HYPERICACEAE

Hypericum cernuum Roxb. (Piunli)	Shrub	Yellow
Hypericum lysimachioides Wall.	Shrub	Yellow
Hypericum perforatum Roxb.	Herb	Yellow

ILIACEAE

Ilex dipyrena Wall.	Shrub	White

IRIDACEAE

Iris nepalensis Don.	Herb	Liliac

	LABIATAE		
Ajuga bracteosa Wall.	Herb	Liliac	
Lamium album Linn.	Herb	White pink	
Micromeria biflora Benth.	Herb	Pink	
Nepeta campestris Benth.	Herb	Blue	152
Nepeta distans Benth.	Herb	Pale pink	
Nepeta linearis Royle	Herb	Blue	
Plectranthus rugosus Wall.	Herb	White	
Salvia lanata Roxb.	Herb	Blue grey	
Scutellaria angulosa Benth.	Herb	White Purple	
	LEGUMINOSAE		
Albizzia julibrissin Durazzini.	Tree	Pink	
Argyrolobium flaccidium Jaub. & Spach	Shrub	Yellow	
Astragalus trichocarpus Grah.	Shrub.	Pink	
Indigofera Dosua Buch-Ham	Shrub	Red	
Indigofera Gerardiana Wall. (Sakina) var. *heterantha*	Shrub	Purple	
Lathyrus aphaca Linn.	Herb	Yellow	
Lathyrus luteus Baker.	Herb	Yellow	
Parochetus communis Buch-Ham	Herb	Violet blue	
Trifolium pratense Linn.	Herb	Purple	
Trifolium repens Linn.	Herb	White	
Vicia tenera Grah.	Herb	Pale pink	
	LILIACEAE		
Lilium nepalense Don.	Herb	White	
Polygonatum verticillatum Allioni	Herb	White green	
Smilax parvifolia Wall. (Kukardara)	Climbing shrub	Purple	
Smilax vaginata Decene.	Climbing shrub	Purple	
	LORANTHACEAE		
Viscum album Linn. (Chulu kabanda)	Shrub	Green	
	MALVACEAE		
Malva verticillata Linn.	Herb	Pale pink	274
	MENISPERMACEAE		
Cissampelos pareira Linn. (Patari)	Climbing Shrub		96
	MYRSINACEAE		
Myrsine africana Linn. (Ghani)	Shrub	Green	
Myrsine semiserrata Wall.	Shrub	Green	
	NAIDACEAE		
Potamogeton pectinatus Linn.	Aquatic herb		
Potamogeton perfoliatus Linn.	Aquatic herb		
	ONAGRACEAE		
Oenothera rosea Sol.	Herb	Pink	

OLEACEAE

Fraxinus floribunda Wall. (Angar. Angu)	Tree	White	
Jasminum grandiflorum Linn. (Chameli)	Shrub	White	
Jasminum humile Linn. (Pili chameli)	Shrub	Yellow	
Jasminum officinale Linn. (Jai)	Climbing Shrub	White	

ORCHIDACEAE

Cypripedium cordigerum Don.	Herb	White green	

POLYGALACEAE

Polygala crotalarioides Buch-Ham	Herb	Purple	141

POLYGONACEAE

Polygonum alatum Buch-Ham.	Herb	White	
var. *metiana*			
var. *parviflora*			
Polygonum amplexicaule Don.	Herb	Red	287
var. *speciosa*			
Polygonum sagittatum Linn.	Herb	Pink	
Rumex hastatus Don. (Almora)	Herb	Green	
Rumex nepalensis Spreng.	Herb	Green	

PRIMULACEAE

Androsace lanuginosa Wall.	Herb	Purple	

RANUNCULACEAE

Aquilegia vulgaris Linn.	Herb	Purple	
Aquilegia pubiflora Don.	Herb	Purple	96
Clematis montana Buch-Ham.	Climbing shrub	White	
var. *major* (Kanguli, Jai)			
Delphinium denudatum Wall.	Herb	Blue	
Ranunculus diffusus DC.	Herb	Yellow	
Ranunculus hirtellus Royle	Herb	Yellow	
Ranunculus laetus Wall.	Herb	Yellow	11

RHAMNACEAE

Berchemia lineata DC. (Kameti)	Shrub	Purple blue	
Rhamnus purpureus Edgew (Luhish)	Shrub	Green	
Rhamnus procumbens Edgew.	Shrub	Green	
Rhamnus virgatus Roxb. (Chedul)	Shrub	Green	

ROSACEAE

Cotoneaster bacillaris Wall. (Ruins)	Shrub	White	
Cotoneaster microphylla Wall. (Gheri)	Shrub	White	
var. *buxifolia*			
Fragaria indica Andr. (Bhiula)	Herb	Yellow	
Fragaria vesca Linn.	Herb	White	
var. *nubicola*			
Geum urbanum Linn.	Herb	Yellow	
Potentilla fragaroides Linn.	Herb	Yellow	
Potentilla kleiniana Wight. & Arn.	Herb	Yellow	
Potentilla nepalensis Hook. f.	Herb	Red	

Pyranthus crenulatus Rehder. (Ghingharu) syn. *Crataegus crenulatus*	Shrub	White
Rosa macrophylla Lindl. (Kunj)	Shrub	Pink
Rosa moschata Mill. (Kunja)	Climbing Shrub	White
Rubus ellipticus Smith. (Hinsalu)	Shrub	White
Rubus niveus Wall.	Shrub	White
Rubus paniculatus Smith (Kathula)	Climbing shrub	White
Rubus rosaefolius Smith	Shrub	White
Spiraea canescens Don. (Miral)	Shrub	White

RUBIACEAE

Galium elegans Wall.	Herb	White green
Galium triflorum Michx.	Herb	White yellow

RUTACEAE

Skimmia laureola Sieb. & Zucc. (Nair, Naira)	Shrub	Yellow white

SABIACEAE

Meliosma pungens Wall. (Gogsha, Bhumis)	Tree	Green

SALICACEAE

Salix babylonica Linn. (Bed majnu)	Tree	Green

SAPINDACEAE

Acer pictum Thunb. (Gaddhpapri)	Tree	White	Green
Acer oblongum Wall. (Putli)	Tree	Green	

SAXIFRAGACEAE

Deutzia corymbosa R.Br. (Bhujroi)	Shrub	White		
Deutzia staminea R. Br. (Ghugti.)	Shrub	White	*Gupta*	294

SCROPHULARIACEAE

Lindenbergia grandiflora Benth.	Herb.	Yellow	
Linaria ramosissima Wall.	Herb.	Yellow	
Verbascum thapsus Linn. (Gidar-tambaku)	Herb	Yellow	Blue
Veronica anagallis Linn.	Herb	Blue	
Veronica argestris Linn.	Herb	Blue	
Veronica biloba Linn.	Herb	Blue	

UMBELLIFERAE

Heracleum canescens Lindl.	Herb	White	315
Heracleum candicans Wall.	Herb	White	
Sanicula europea Linn.	Herb	White	

URTICACEAE

Celtis australis Linn. (Kharik)	Tree	Pale yellow
Parietaria debilis Forst.	Tree	Green

VALERIANACEAE

Valeriana wallichii D.C. (Semwa)	Herb	White pink

VERBENACEAE

Verbena officinalis Linn.	Herb	Liliac	22

VIOLACEAE

Viola canescens Wall. (benefsha)	Herb	Liliac	

VITACEAE

Vitis himalayana Brandis (Bhinana)	Climber	Yellow green	
Vitis obtecta Wall.	Climber	Green	
Vitis parvifolia Roxb.	Climber	Green	

Plants flowering in the month of June

ACANTHACEA

Dicliptera bupleuroides Nees.	Herb	Pink	
Justicia simplex Don.	Herb	Pale purple	

AMARANTACEAE

Achyranthes aspera Linn. (Chirchita) var. *phorphyristachya*	Shrub	Green purple	
Achyranthes bidentata Blume	Shrub	Green purple	
Celosia argentea Linn. (Sufed murg ka-phul)	Herb	White	

ANACARDIACEAE

Rhus wallichii Hook. f. (Konki)	Tree	Green yellow	307

ARACEAE

Arisaema consanguineum Schott.	Herb	Spathe	Green yellow
Arisaema intermedium Blume.	Herb	Spathe	Green yellow
Arisaema jacquemontii Blume	Herb	Spathe	Green yellow
Arisaema tortuosum Schott.	Herb	Spathe	Green yellow

ASCLEPIDIACEAE

Caropegia wallichii Wight.	Herb	Red brown	
Cynanchum auriculatum Wall.	Herb	Yellow green	
Cynanchum glaucum Wall.	Herb	White	
Marsdenia Roylei Wight. (Murkhila)	Shrub	Orange	

BERBERIDACEAE

Berberis aristata DC. var. *floribunda* (Kilmora)	Shrub	Yellow	

BORAGINACEAE

Cynoglossum furcatum Wall.	Herb	Pale blue	115
Cynoglossum micranthum Desf.	Herb	Pale blue	
Cynoglossum wallichii G.Don. syn. *Cynoglossum denticulatum*	Herb	Blue	49

CAMPANULACEAE

Campanula colorata Wall.	Herb	Liliac	

CAPRIFOLIACEAE

*Abelia triflora*R.Br. (Bedra)	Shrub	Pale pink
Lonicera quinquelocularis Hardw. (Bhanti)	Shrub	Yellow
Viburnum stellulatum Wall. (Maleo)	Tree	White

CARYOPHYLLACEAE

Cerastium vulgatum Linn.	Herb	White
Gypsophila cerastioides D. Don.	Herb	White
Stellaria bulbosa Wulf.	Herb	White
Stellaria longissima Wall.	Herb	White

CELASTRACEAE

Euonymus pendulus Wall. (Chopri, Karrek)	Tree	White

CHENOPODIACEAE

Chenopodium album Linn. (Bethwa)	Herb	Green

COMPOSITAE

Anaphalis araneosa DC.	Herb	White	
Aster molliusculus Wall.	Herb	Liliac	
Carduus nutans Linn.	Herb	Red	
Erigeron linifolius Willd.	Herb	Pale purple	325
Erigeron multicaulis DC.	Herb	Pale purple	
Erigeron multiradiatus Benth.	Herb	Purple	
Galinsoga parviflora Cav.	Herb	White yellow	
Gerbera gossypiana Royle	Herb	Pink	
Gnaphalium luteo-album Linn.	Herb	Yellow	
Serratula pallida DC.	Herb	Purple	
Solidago virga-aurea Linn.	Herb	Yellow	-200
Taraxacum officinale Wigg.	Herb	Yellow	
Tragopogon gracile Don.	Herb	Yellow	

COMMELINACEAE

Cyanotis barbata Don.	Herb	Blue

CRASSULACEAE

Sedum multicaule Wall.	Herb	Yellow
Sedum rosulatum Edgew.	Herb	White

CRUCIFERAE

Arabis glabra Bernh.	Herb	White
Capsella Bursa-pastoris Medic.	Herb	White
Cardamine macrophylla Medic.	Herb	White
Nasturtium montanum Wall.	Herb	Yellow
Nasturtium officinale R.Br. (Pania)	Herb	White

CUPULIFERAE

Betula alnoides Buch-Ham (Saur)	Tree	Green

DIPSACACEAE

Morina persica Linn.	Shrub	White pink

	DIOSCOREACEAE		
Dioscorea deltoidea Wall. (Gethi)	Climber	White	
	ELAEAGNACEAE		
Hippophae salicifolia Don. (Ames, Chuk)	Herb	Green	
	EUPHORBIACEAE		
Andrachne cordifolia Muell-Arg. (Bhatula)	Shrub	Green	
	GERANIACEAE		
Geranium nepalense Sweet	Herb	Pale purple	
Oxalis acetosella Linn. (Tipatia)	Herb	Pink purple	
Oxalis corniculata Linn. (Amelda)	Herb	Yellow	
	HAEMODORACEAE		
Ophiopogon intermedius Don.	Herb	White liliac	105
	HALORRHAGIDACEAE		
Myriophyllum spicatum Linn.	Herb	Green	39, 80
	HYPERICACEAE		
Hypericum lysimachoides Wall.	Shrub	Yellow	
Hypericum perforatum Linn.	Herb	Yellow	
	IRIDACEAE		
Iris Kumaonensis Wall.	Herb	Liliac	
Iris nepalensis Don.	Herb	Liliac	
	JUNCACEAE		
Juncus glaucus Ehrh.	Herb	White brown	
Juncus prismatocarpus R. Br.	Herb	White brown	
	LIBIATAE		
Ajuga bracteosa Wall.	Herb	Liliac	
Colquhounia coccinea Wall. (Pothi)	Shrub	Red	235
Lamium album Linn.	Herb	White pink	
Micromeria biflora Benth	Herb	Pink	
Nepeta campestris Benth.	Herb	Blue	
Nepeta distans Benth.	Herb	Pale pink	
Plectranthus rugosus Wall. (Kurkha)	Herb	White	
Salvia lanata Roxb.	Herb	Blue Grey	
Scutellaria grossa Wall.	Shrub	Blue	
	LEGUMINOSAE		
Albizzia julibrissin Durazzini	Tree	Pink	
Argyrolobium flaccidum Jaub & Spach.	Shrub	Yellow	
Desmodium floribundum G. Don.	Shrub	Pink purple	
Desmodium laxiflorum DC.	Shrub	Pink purple	
Indigofera artopurpurea Buch-Ham	Shrub	Purple red	
Indigofera cylindracea Wall.	Shrub	Purple red	
Indigofera Dosua Buch-Ham	Shrub	Red	
Indigofera Gerardiana Wall. (Sakina) var. *heterantha*	Shrub	Purple	
Lathyrus luteus Baker	Herb	Yellow	

Medicago falcata Linn.	Herb	Yellow
Melilotus alba Lam.	Herb	White
Parochetus communis Buch-Ham	Herb	Violet blue
Trifolium pratense Linn.	Herb	Red purple
Trifolium repens Linn.	Herb	White pink
Trigonella pubescens Edgew.	Herb	Pale yellow
	LILIACEAE	
Asparagus filicinus Buch-Ham. (Kairua)	Shrub	White
Lilium nepalense Don.	Herb	White
Polygonatum verticillatum Allioni	Herb	White green
	MALVACEAE	
Malva rotundifolia Linn.	Herb	Pale liliac
Malva sylvestris Linn.	Herb	Pale purple
Malva verticillata Linn.	Herb	Pale pink
	MENISPERMACEAE	
Cissampelos pareira Linn. (Patari)	Climbing Shrub	
	NAIDACEAE	
Potamogeton indicus Roxb.	Herb aquatic	Green
Potamogeton pectinatus Wall.	Herb aquatic	Green
Potamogeton perfoliatus Linn.	Herb aquatic	Green
	OLEACEAE	
Jasminum grandiflorum Linn. (Chambeli)	Shrub	White
Jasminum humile Linn. (Pili chembeli)	Shrub	Yellow
Jasminum officinale Linn. (Jai)	Shrub	White
	ONAGRACEAE	
Epilobium roseum Schieb.	Herb	Pale pink
Epilobium Royleanum Hausskn. Monogr. Epilob.	Herb	Pale pink
Oenothera rosea Sol.	Herb	Pale pink
	ORCHIDACEAE	
Cyperipedium cordigerum Don.	Herb	White green
	POLYGALACEAE	
Polygala crotalarioïdes Buch-Ham	Herb	Purple
	POLYGONACEAE	
Polygonum alatum Buch-Ham var. *Metziana* var. *parviflora*	Herb	Purple
Polygonum amplexicaule var. *speciosa* Don.	Herb	Red
Polygonum pterocarpum Wall.	Herb	Green pink
Rumex hastatus Don. (Almora)	Herb	Green
Rumex nepalensis Spreng.	Herb	Green
	RANUNCULACEAE	
Anemone obtusiloba D. Don.	Herb	White blue

Aquilegia pubiflora Wall.	Herb	Pale purple	
Clematis barbellata Edgew.	Climber	Purple white	
Clematis nepaulensis DC. (Jai)	Climber	White yellow	
Delphinium denudatum Wall.	Herb	Blue	
Ranunculus diffusus DC.	Herb	Yellow	247
Ranunculus hirtellus Royle	Herb	Yellow	
Ranunculus laetus Wall	Herb	Yellow	
Thalictrum foliolosum DC. (Mamiri)	Herb	White	11

RHAMNACEAE

Berchemia lineata DC. (Kameti)	Shrub	Purple blue
Rhamnus procumbens Edgew.	Shrub	Green
Rhamnus triqueter Wall. (Gaunt)	Shrub	Green
Rhamnus virgatus Roxb. (Chedul)	Shrub	Green

ROSACEAE

Agrimonia Eupatorium Linn.	Herb	Yellow
Cotoneaster bacillaris Wall. (Ruins)	Shrub	White
Cotoneaster microphylla Wall. (Gheri) var. *buxifolia*	Shrub	White
Fragaria vesca var. nubicola Linn.	Herb	White
Geum urbanum Linn.	Herb	Yellow
Potentilla fragarioides Linn.	Herb	Yellow
Potentilla Kleiniana Wight. & Arn.	Herb	Yellow
Potentilla nepalensis Hook. f.	Herb	Red
Rosa moschata Mill. (Kunja)	Shrub climbing	White
Rubus paniculatus Smith. (Kathula)	Shrub climbing	White
Rubus niveus Wall. (Bhera)	Shrub	White
Spiraea canescens Don. (Mairala)	Shrub	White

RUBIACEAE

Galium elegans Wall.	Herb	White green
Galium rotundifolium Linn.	Herb	White green
Galium triflorum Michx.	Herb	White yellow
Leptodermis lanceolata Wall. (Padhera)	Shrub	White purple

SABIACEAE

Meliosma dillenifolia Wall. (Goguna)	Tree	Green
Meliosma pungens Wall. (Goguna, Gogsha)	Tree	Green

SAXIFRAGACEAE

Deutzia corymbosa R. Br. (Bhujroi)	Shrub	White
Deutzia staminea R.Br. (Gugti)	Shrub	White

SCROPHULARIACEAE

Linaria ramosissima Wall.	Herb	Yellow
Lindenbergia grandiflora Benth.	Herb	Yellow
Mazus rugosus Lour.	Herb	Pale blue
Veronica argestris Linn.	Herb	Blue
Veronica anagallis Linn.	Herb	Blue
Veronica biloba Linn.	Herb	Blue
Verbascum thapsus Linn. (Gidar tambaku)	Herb	Yellow

SOLANCEAE

Datura stramonium Linn. (Dhatura)	Herb	White	
Solanum nigrum Linn. (Makoi)	Herb	White	

THYMELAEACEAE

Wikstroemia canescens Meissn.	Shrub	Yellow	

UMBELLIFERAE

Angelica glauca Edgew.	Herb	White	447
Heracleum canescens Lindl.	Herb	White	315
Heracleum candicans Wall.	Herb	White	
Sanicula europaea Linn.	Herb	White	

URTICACEAE

Elatostemma sessile Forst. var. *cuspidata*	Herb	Green	
Parietaria debilis Forst.	Herb	Green	
Pilea scripta Wedd.	Herb	Green	
Pilea umbrosa Wedd.	Herb	Green	

VERBEINACEAE

Verbena officinalis Linn.	Herb	Liliac	

VIOLACEAE

Viola canescens Wall. (Banefsha)	Herb	Liliac	

VITACEAE

Vitis divaricata Wall.	Climbing Shrub	Red brown	

Plants flowering in the month of July

ACANTHACEAE

Barleria prionitis Linn.	Herb		
Dicliptera bupleuroides Nees.	Herb	Pink	
Justicia simplex Don.	Herb	Pale purple	
Strobilanthes Dalhousianus C.B. Clarke (Patheura)	Shrub	Blue	261

AMARANTACEAE

Achyranthes aspera Linn. (Chirchita) var. *phorphyristachya*	Shrub	Green purple	
Achyranthes bidentata Blume	Shrub	Green purple	
Celosia argentea Linn. (Sufed murg ka phul)	Herb	White	

ARACEAE

Arisaema curvatum Kunth.	Herb	Spathe Pale green	372
Arisaema intermedium Blume	Herb	Spathe Green white	
Arisaema jacquemontii Blume	Herb	Spathe Green white	
Typhonium diversifolium Wall. (Syapak mam)	Herb	Spathe green	

ASCLEPEDIACEAE

Caropegia wallichii Wight.	Herb	Red purple	

Cynanchum auriculatum Wight.	Herb	Yellow green	
Cynanchum glaucum Wall.	Herb	White	
Marsdenia Roylei Wight. (Murkhila)	Shrub	Orange	103

BIGONIACEAE

Bigonia amoena Wall.	Herb	Pale pink	145, 184
Bigonia picta Smith	Herb	Pale pink	183

BORAGINACEAE

Cynoglossum furcatum Wall.	Herb	Pale blue	
Cynoglossum micranthum Desf.	Herb	Pale blue	
Cynoglossum wallichii G.Don.	Herb	Blue	

CAMPANULACEAE

Campanula colorata Wall.	Herb	Pale liliac	

CAPRIFOLIACEAE

Leycesteria formosa Wall.	Shrub	White purple	
Viburnum coriaceum Blume (Tita, Titmula)	Tree	White	66
Viburnum stellulatum Wall. (Maleo, Titmoolia)	Tree	White	

CARYOPHYLLACEAE

Cerastium vulgatum Linn. (Bethura)	Herb	White	
Lychnis nutans Benth.	Herb	Purple	260
Stellaria longissima Wall.	Herb	White	

CHENOPODIACEAE

Chenopodium album Linn. (Bethwa)	Herb	Green	

COMPOSITAE

Anaphalis triplinervis C.B. Clarke	Herb	White	154,202
Aster asperculus Nees.	Herb	Liliac	219
Aster molluisculus Wall.	Herb	Liliac.	
Crepis japonica Benth.	Herb	Red	
Erigeron linifolius Willd.	Herb	White purple pink	
Erigeron multicaulis DC.	Herb	Purple	
Erigeron multiradiatus Benth. Benth. var. *obovatus*	Herb	Purple	
Galinsoga parviflora Cav.	Herb	White yellow	
Gerbera gossypiana Royle	Herb	Pink	
Gnaphalium luteo-album Linn.	Herb	Yellow	
Senecio rufinervis DC.	Herb	Yellow	
Senecio chrysanthemoides DC.	Herb	Yellow	308
Solidago virga-aurea Linn.	Herb	Yellow	
Sonchus arvensis Linn.	Herb	Yellow	
Sonchus oleraceus Linn. var. *asper*	Herb	Yellow	373
Taraxacum officinale Wigg. var. *eriopoda*	Herb	Yellow	
Tragopogon gracile Don	Herb	Yellow	

COMMELINACEAE			
Commelina obliqua Buch-Ham	Herb	Pale blue	197
Cyanotis barbata Don.	Herb	Blue	
CRASSULACEAE			
Sedum multicaule Wall.	Herb	Yellow	
Tillaea pentendra Royle	Herb	Pink white	
CRUCIFERAE			
Arabis glabra Bernh.	Herb	White	
Capsella Bursa-pastoris Medic.	Herb	White	
Nasturtium montanum Wall.	Herb	White	
Nasturtium officinale R. Br.	Herb	White	
Sisymbrium strictum Hoof. f. & Thomas	Herb	White	
DIPSACEAE			
Dipsacus inermis Wall.	Shrub	White	272
DIOSCOREACEAE			
Dioscorea deltoidea Wall. (Gethi)	Climber	White	
ELAEAGNACEAE			
Hippophae salicifolia Don. (Ames, Chuk)	Herb	White	
EUPHORBIACEAE			
Acalypha brachystachya Hornem.	Herb	Green	
Andrachne cordifolia Muell.& Arg.(Bhatula)	Herb	Green	
GERANIACEAE			
Geranium nepalense Sweet	Herb	Purple	
Geranium wallichianum Sweet.	Herb	Blue purple	107, 149
Impatiens scabrida DC.	Herb	Yellow	206
Oxalis corniculata Linn.	Herb	Yellow	
Oxalis acetosella Linn. (Tipatia)	Herb	Purple pink	
HALORRHAGIDACEAE			
Myriophyllum spicatum Linn.	Herb	Aquatic	39, 80
HAEMODORACEAE			
Ophiopogon intermedius Don.	Herb	White Liliac	105
JUNCACEAE			
Juncus glaucus Ehrh.	Herb	White brown	
Juncus prismatocarpus R.Br.	Herb	White brown	
LABIATAE			
Ajuga bracteosa Wall.	Herb	Liliac	
Calamintha umbrosa Benth.	Herb	Pink purple	242
Craniotome versicolor Reichb.	Herb	White pink	241
Lamium album Linn.	Herb	White pink	
Leucas cephalotes Spreng.	Herb	White	337
Leucas lanata Benth.	Herb	White	161

Micromeria biflora Benth. Smith	Herb	Pink	
Nepeta campestris Benth.	Herb	Blue	
Nepeta ciliaris Benth.	Herb	Liliac	
Nepeta distans Benth.	Herb	Pale pink	
Nepeta elliptica Royle	Herb	Pale blue	239
Nepeta leucophylla Benth.	Herb	Liliac	148
Nepeta spicata Benth.	Herb	Purple blue	222
Plectranthus rugosus Wall. (Kurkha)	Herb	White	
Salvia glutinosa Linn.	Herb	Yellow purple	
Saliva lanata Roxb.	Herb	Blue grey	338
Salvia moorcroftiana Wall.	Herb	Pale blue	
Scutellaria grossa Wall.	Herb	Blue	
Stachys sericea Wall.	Herb	Pink purple	221
Teucrium Royleanum Wall.	Herb	White	

LEGUMINOSAE

Argyrolobium flaccidum Jaub. & Spach.	Shrub	Yellow	
Crotalaria albida Heyne	Herb	Pale yellow	
Crotalaria sericea Retz.	Shrub	Yellow	
Desmodium floribundum G. Don.	Shrub	Pink purple.	
Desmodium oxyphyllum Dc.			
Desmodium podocarpum DC. (Matoi)	Shrub	Pink	
Desmodium tiliaefolium G.Don. (Chamlai)	Shrub	Pale pink	
Indigofera atropurpurea Buch-Ham.	Shrub	Purple red	
Medicago falcata Linn.	Herb	Yellow	
Melilotus alba Lam.	Herb	Yellow	
Parochetus communis Buch-Ham	Herb	Violet blue	
Rhynchosia himalensis Benth.	Shrub	Yellow purple	
Trifolium pratense Linn.	Shrub	Red purple	
Trifolium repens Linn.	Herb	White	
Trigonella gracilis Benth.	Herb	Yellow	40
Trigonella pubescens Edgew.	Herb	Yellow	
Vicia rigidula Royle	Herb	Purple	211
Vicia sativa Linn.	Herb	Red blue	

LILIACEAE

Polygonatum verticillatum Allioni	Herb	White green

MALVACEAE

Malva verticillata Linn.	Herb	Pale pink

MENISPERMACEAE

Cissampelos praiera Linn. (Patari)	Climber

NAIDACEAE

Potamogeton pectinatus Linn.	Herb Aquatic	Green
Potamogeton perfoliatus Linn.	Herb Aquatic	Green

NYCTAGINAGEAE

Mirabilis jalapa (Gule-bas)	Herb	Purple

Oleaceae

Jasminum grandiflorum Linn. (Chameli)	Shrub	White	
Jasminum humile Linn. (Pili chameli)	Shrub	Yellow	
Jasminum officinale Linn. (Jai) Climbing	Shrub	White	

Onagraceae

Epilobium Royleanum Haussk. Monogr. Epilob.	Herb	Pale pink	
Oenothera rosea Sol.	Herb	Pink	

Orchidaceae

Hermium angustifolium Benth.	Herb	Green	

Plantaginaceae

Plantago major Linn.	Herb	Green	

Polygonaceae

Fagopyrum cymosum Meissn. (Ban-Ogal)	Herb	White	355
Fagopyrum esculentum Moench. (Ogal)	Herb	White	
Polygonum alatum Buch-Ham (Ameti)	Herb	White	
Polygonum amplexicaule var. *speciosa* Don.	Herb	Red	
Polygonum glabrum Willd.	Herb	White pink	
Polygonum lapathifolium Linn.	Herb	Aquatic pink	
Polygonum polystachyum Wall.	Herb	White pink	
Polygonum pterocarpum Wall.	Herb	Green pink	232
Polygonum sagittatum Linn.	Herb	Pink	
Rumex hastatus Don. (Almora)	Herb	Green	
Rumex nepalensis Spreng.	Herb	Green	
Rumex orientalis Bernha.	Herb	Green	234

Polygalaceae

Polygala crotalaroides Buch-Ham.	Herb	Purple	

Ranunculaceae

Anemone vitifolia Buch-Ham.	Herb	White	246
Clematis connata var. *wallichii* (Jai)	Climbing Shrub	Yellow white	
Ranunculus diffusus D C.	Herb	Yellow	248
Ranunculus laetus Wall.	Herb	Yellow	
Thalictrum foliolosum D C. (Man.ira)	Herb	White	447
Thalictrum punduanum Wall.	Herb	White	
Thalictrum saniculaeforme D C.	Herb	White	

Rhamnaceae

Berchemia lineata D C. (Kameti)	Shrub	Purple blue	

Rosaceae

Agrimonia Eupatorium Linn.	Herb	Yellow	
Geum urbanum Linn.	Herb	Yellow	
Potentilla fragarioides Linn.	Herb	Yellow	
Potentilla Kleiniana Wight. & Arn.	Herb	Yellow	
Potentilla nepalensis Hook. f.	Herb	Red	
Rubus niveus Wall. (Bhera)	Herb	White	

RUBIACEAE

Galium Asperine Linn.	Herb	White green	
Galium rotundifolium Linn.	Herb	White green	
Leptodermis lanceolata Wall. (Padhera)	Shrub	White purple	
Rubia cordifolia Linn. (Majithi)	Climber	Red	172

RUTACEAE

Boenninghausenia albiflora Reichenb. (Pissumar)	Herb	White	122, 208

SABIACEAE

Meliosma dilleniaefolia Wall. (Goguna, Gweb)	Tree		

SAXIFRAGACEAE

Astilbe rivularis Buch-Ham.	Herb	Green yellow	
Parnassia nubicola Wall.	Herb	White	188

SCITAMINEAE

Roscoea procera Wall. (Musli)	Herb	Liliac	

SCROPHULARIACEAE

Lindenbergia grandiflora Benth	Herb	Yellow	
Mazus rugosus Lour.	Herb	Pale blue white	
Sopubia trifida Buch-Ham.	Herb	Yellow	
Verbascum thapsus Linn. (Gidar-Tambaku)	Herb	Yellow	
Veronica agrestis Linn.	Herb	Pink	
Veronica anagallis Linn.	Herb	Pale pink	
Veronica biloba Linn.	Herb	Blue	
Wulfenia Amherstiana Benth.	Herb	Blue purple	76, 87

SOLANACEAE

Datura stramonium Linn. (Dhatura)	Herb	White	
Nicandra physaloides Gaertn.	Herb	Blue	
Physalis peruviana Linn.	Herb		
Solanum nigrum Linn. (Makoe)	Herb	White	

THYMELAEACEAE

Wikstroemia canescens Meissn. (Chambai)	Shrub	Yellow	

UMBELLIFERAE

Angelica glauca Edgew.	Herb	White	
Bupleurum candillii Wall. var. *marginatum* var. *Hoffmesteri*	Herb	Yellow	
Caucalis anthriscus Scop.	Herb	Pale pink	
Heracleum canescens Lindl.	Herb	White	315
Heracleum candicans Wall.	Herb	White	
Ligusticum elatum C.B. Clarke.	Herb	White	
Vicatia coniifolia DC.	Herb	Red	

URTICACEAE

Cannabis sativa Linn. (Bhang)	Herb	Yellow green	340
Elatostemma sessile Forst var. *cuspidata*	Herb	Green	
Gerardinia heterophylla Dece. (Bitchu-ghass)	Herb	Green	451
Lecanthus wightii Wedd.	Herb	Pink	165
Lecanthus wallichii Wedd.	Herb	Pink	
Parietaria debilis Forst	Herb	Green	
Pilea scripta Wedd	Herb	Green	
Pilea umbrosa Wedd.	Herb	Green	
Urtica parviflora Roxb.	Herb	Green	452

VIOLACEAE

Viola canescens Wall. (Banefsha)	Herb	Liliac	

VITACEAE

Vitis capriolata D. Don.	Climbing Shrub	Yellow green	
Vitis rugosa Wall. (Chipari)	Sca. Shrub	Green	

Plants flowering in the month of August

ACANTHACEAE

Barleria cristata Linn.	Herb	Liliac pink	268
Dicliptera bupleuroides Nees	Herb	Pale purple	
Justicia simplex Don.	Herb	Pale purple	
Strobilanthes Dalhousianus C.B.Clarke (Patheura)	Shrub	Blue	

AMARANTACEAE

Achyranthes aspera Linn. (Chirchita)	Shrub	Green purple	
Achyranthes bidentata Blume. var. *porphyristachya*	Shrub	Green purple	
Celosia argentea Linn.	Herb	White	
Cyathula tomentosa Moq. (Lich-kura)	Shrub	White	231

ARACEAE

Arisaema curvatum Kunth	Herb	Spathe green	

ASCLEPEDIACEAE

Cynanchum auriculatum Royle	Twiner	Yellow green	
Cynanchum Dalhousiae Wight.	Twiner	Yellow green	
Marsdenia Lucidum Edgew	Twiner	Purple	
Marsdenia Roylei Edgew. (Murkhila)	Twiner	Orange	

BEGONIACEAE

Begonia amoena Wall	Herb	Pale pink	
Begonia picta Smith	Herb	Pale pink	

BORAGINACEAE

Cynoglossum denticulatum D C. syn. *Cynoglossum wallichii*	Herb	Blue	

COMPOSITAE (*Contd.*)

Cynoglossum furcatum wall.	Herb	Pale blue	
Cynoglossum micranthum Desf.	Herb	Pale blue	

CAMPANULACEAE

Campanula colorata Wall.	Herb	Pale liliac	

CAPRIFOLIACEAE

Viburnum coriaceum Blume (Gwia)	Herb	White	

CARYOPHYLLACEAE

Cerastium vulgatum Linn.	Herb	White	
Lychnis nutans Benth.	Herb	Purple	

CHENOPODIACEAE

Chenopodium album Linn. (Bethwa)	Herb	Green	

COMPOSITAE

Anaphalis triplinervis C.B. Clarke	Herb	White	
Artemisia vulgaris Linn. (Kunj)	Herb	Green	
Aster asperculus Nees.	Herb	Purple	
Aster molliusculus Wall.	Herb	Purple	
Bidens wallichii D C.	Herb	Liliac	
Carduus nutans Linn.	Herb	Crimson	190
Carpesium cernuum Linn.	Herb	Yellow	
Dichrocephala latifolia D C.	Herb	White yellow	
Erigeron linifolius Willd.	Herb	Pale purple white	
Erigeron multicaulis Wall.	Herb	Purple	
Erigeron multiradiatus Benth.	Herb	Purple	
Echinops cornigerus DC.	Herb	Pale blue	298
Echinops niveus Wall.	Herb	Pale blue	
Galinsoga parviflora Cav.	Herb	White yellow	
Gerbera gossypiana Royale	Herb	Pink	
Lactuca hastata DC.	Herb	Blue	245
Lactuca macrorhiza Hook. f.	Herb	Grey purple	243
Myriactis wallichii Less.	Herb	Yellow	
Senecio chrysanthemoides Don.	Herb	Yellow	
Senecio rufinervis DC.	Herb	Yellow	
Solidago virga-aurea Linn.	Herb	Yellow	
Sonchus arvensis Linn.	Herb	Yellow	
Sonchus oleraceous Linn.	Herb	Yellow	
Taraxacum officinale Wigg.	Herb	Yellow	
Tragopogon gracile Don.	Herb	Yellow	
Veronia cinerea Less.	Herb	Purple	

COMMELINACEAE

Commelina obliqua Buch-Ham. (Kana, Kanjura)	Herb	Pale blue	
Cyanotis barbata Don.	Herb	Blue	

CONVOLVULACEAE

Ipomaea purpurea Lam.	Twining Herb	Pink Blue	

CRASSULACEAE				
Sedum trifidum Wall.	Herb	Pale pink		
Tillaea pentendra Royle	Herb	Pink white		
CRUCIFERAE				
Capsella Bursa-pastoris Medic.	Herb	White		
Eruca sativa Mill.	Herb	Yellow white		
Nasturtium montanum Wall.	Herb	Yellow		
Nasturtium officinale R. Br.	Herb	White		
CYPERACEAE				
Eriophorum cosmosum Wall.	Herb	Brown		180
DIPSACACEAE				
Dipsacus inermis Wall.	Herb	White		180
DROSERACEAE				
Drosera lunata Buch-Ham. (Mukha-Jali)	Herb	White		
EUPHORBIACEAE				
Acalypha brachystachya Hornem.	Herb	Green		
Andrachnecordifolia Muell.& Arg.(Bhatula)	Shrub	Green		
GERANIACEAE				
Geranium nepalense Sweet.	Herb	Pale purple		
Geranium wallichianum Sweet.	Herb	Purple blue		
Impatiens amphorata Edgew.	Herb	Purple		
Impatiens racemosa DC. var. *eclarata*	Herb	Yellow		
Impatiens scabrida DC.	Herb	Yellow		
Oxalis corniculata Linn. (Tipatia)	Herb	Yellow		
GENTIANACEAE				
Gentiana contorta Royle	Herb	Blue		
Swertia chirata Buch-Ham. (Chirayta)	Herb	Yellow purple		
Swertia cordata Wall.	Herb	Yellow white		
Swertia lurida Royle	Herb	White	Yellow	
GESNERACEAE				
Platystemma violoides Wall.	Herb	Blue		
HAEMODORACEAE				
Ophiopogon intermedius Don.	Herb	Whiteliliac		
HALORHAGIDACEAE				
Myriophyllum spicatum Linn.	Aquatic	Herb		
HYPERICACEAE				
Hypericum elodeoides Choisy	Herb	Yellow		
Hypericum perforatum Linn.	Herb	Yellow		

Juncaceae

Juncus bufonius Linn.	Herb	Whitebrown
Juncus prismatocarpus R.Br.	Herb	Whitebrown

Labiatae

Ajuga bracteosa Wall.	Herb	Liliac
Calamintha umbrosa Benth.	Herb	Pinkpurple
Colquhounia coccinea Wall. (Pothi)	Herb	Orange
Craniotome versicolor Reichb.	Herb	Whitepink
Lamium album Linn.	Herb	Palepink
Leucas lanata Benth.	Herb	White
Micromeria biflora Benth	Herb	Pink
Nepeta campestris Benth	Herb	Blue
Nepeta ciliaris Benth.	Herb	Liliac
Nepeta distans Linn.	Herb	Palepink
Nepeta elliptica Royle.	Herb	Paleblue
Nepeta leucophylla Benth.	Herb	Liliac
Plectranthus coetsa Buch-Ham. (Molchara)	Herb	Blue
Plectranthus Gerardianus Benth.	Herb	White
Plectranthus rugosus Wall. (Kurkha)	Herb	White
Plectranthus striatus Benth	Herb	White
Salvia glutinosa Linn.	Herb	Yellowpurple
Scutellaria grossa Wall.	Shrub	Blue
Stachys sericea Wall	Herb	Pinkpurple
Teucrium quadrifarium Buch-Ham.	Herb	Pinkpurple

Leguminosae

Astragalus chlorostachys Lindl.	Shrub	Yellowgreen
Atylosia platycarpa Benth.	Shrub	Yellow
Crotalaria albida Heyne	Shrub	Paleyellow
Crotalaria sericea Retz.	Shrub	Paleyellow
Desmodium concinnum DC.	Shrub	Blue
Desmodium floribundum DC.	Shrub	Pink
Desmodium podocarpum DC. (Matoi)	Shrub	Pink
Desmodium tillaefolium Don. (Chamlai)	Shrub	Palepink
Medicago falcata Linn.	Herb	Yellow
Meliolotus alba Lam.	Herb	White
Moghania fructiculosa syn. *Flemingia fructiculosa* Wall.	Shrub	Pinkwhite
Parochetus communis Buch-Ham.	Herb	Violetblue
Trigonella gracilis Benth.	Herb	Yellow
Trigonella pubescens Edgew.	Herb	Yellow
Vicia rigidula Royle	Herb	Purpleblue

Magnoliaceae

Michelia champaca (Champa)	Tree	Yellow

Malvaceae

Malva verticillata Linn.	Herb	Pale pink

Menispermaceae

Stephania elegans Hook. f. & Thomas	Climbing Shrub	Purple

NAIDACEAE

Potamogeton pectinatus Linn.	Herb	Aquatic
Potamogeton perfoliatus Linn.	Herb	Aquatic
Najas major Allioni	Herb	Aquatic

NYCTAGINACEAE

Mirabilis jalapa (Gule-bas)	Herb	Purple

OLEACEAE

Jasminum grandiflorum Linn. (Chameli)	Shrub	Yellow
Jasminum humile Linn. (Pili Chameli)	Shrub	Yellow

ONAGRACEAE

Epilobium cylindricum Don.	Herb	Pale pink
Epilobium hirsutum Linn.	Herb	Pink purple

ORCHIDACEAE

Habenaria intermedia Don.	Herb	Green white
Satyrium nepalense Don. (Masal misri)	Herb	Pink

PAPAVERACEAE

Corydalis cornuta Royle.	Herb	Yellow purple

PLANTAGINACEAE

Plantago major Linn.	Herb	Green

POLYGONACEAE

Fagopyrum cymosum Meissn. (Banogal)	Herb	White
Fagopyrum esculentum Moench. (Ogal)	Herb	White
Polygonum alatum Buch-Ham. (Ameta)	Herb	White
Polygonum amplexicaule Don. var. *speciosa*	Herb	Red
Polygonum pterocarpum Wall.	Herb	Green purple
Polygonum recumbens Royle	Herb	White pink
Polygonum sagittatum Linn.	Herb	Pink
Rumex hastatus Don. (Almora)	Herb	Green
Rumex nepalensis Spreng.	Herb	Green
Rumex orientalis Bernh.	Herb	Green

POLYGALACEAE

Polygala crotaloroides Buch-Ham	Herb	Purple

RANUNCULACEAE

Anemone rivularis Buch-Ham.	Herb	White purple	36
Anemone vitifolia Buch-Ham.	Herb	White	
Clematis connata DC. (Jai)	Climbing Shrub	Yellow white	
Ranunculus laetus Wall.	Herb	Yellow	

ROSACEAE

Agrimonia Eupatorium Linn.	Herb	Yellow
Potentilla fragarioides Linn.	Herb	Yellow
Potentilla fulgens Wall.	Herb	Orange yellow

RUBIACEAE

Anotis calycina Wall.	Herb	White pale liliac
Galium Aparine Linn.	Herb	White green
Galium rotundifolium Linn.	Herb	White green
Leptodermis lanceolata Wall. (Padhera)	Shrub	Yellow
Rubia cordifolia Linn. (Majithi)	Climber	Red

RUTACEAE

Boenninghausenia albiflora Reichenb. (Pissumar)	Herb	White

SAXIFRAGACEAE

Astilbe rivularis Buch-Ham.	Herb	Green yellow
Parnassia nubicola Wall.	Herb	White
Saxifraga Brunoniana Wall. (Musli)	Herb	Yellow

SCITAMINEAE

Hedychium spicatum (Haldu, Kapurkachri) syn. *Hedychium acuminatum* Wall.	Herb	White orange	
Roscoea procera Wall. (Musli)	Herb	Liliac	196

SCROPHULARIACEAE

Lindenbergia grandiflora Benth.	Herb	Yellow
Pedicularis pectinata Wall.	Herb	Pink
Scrophularia himalensis Royle	Herb	Green purple
Sopubia trifida Buch-Ham.	Herb	Yellow
Veronica agrestis Linn.	Herb	Yellow
Veronica biloba Linn.	Herb	Blue
Verbascum thapsus Linn. (Gidar tambaku)	Herb	Yellow
Wulfenia Amherstiana Benth	Herb	Blue purple

SOLANACEAE

Datura stramonium Linn. (Dhatura)	Herb	White
Nicandra physaloides Gaertn.	Herb	Blue
Solanum nigrum Linn. (Makoi)	Herb	White

THYMELAEACEAE

Wikstraemia canescens Meissn.	Shrub	Yellow

UMBELLIFERAE

Angelica glauca Edgew.	Herb	White
Bupleurum Candollii Wall.	Herb	Yellow
Bupleurum falcatum Linn.	Herb	Yellow
Bupleurum lanceolatum Wall.	Herb	Yellow
Bupleurum tenue D. Don.	Herb	Yellow
Caucalis anthriscus Scop.	Herb	White
Heracleum canescens Lindl.	Herb	White
Ligusticum elatum C.B. Clarke	Herb	White
Pimpinella acuminata C.B. Clake	Herb	White
Pimpinella diversifolia DC.	Herb	White
Sanicula europea Linn.	Herb	White

Selinum tenuifolium Wall. var. *elata*	Herb	White
Vicatia coniifolia DC.	Herb	White

URTICACEAE

Cannabis sativa Linn. (Bhang)	Herb	Yellow green
Elatostema sessile Forst. var. *cuspidata*	Herb	Green
Gerardiana heterophylla Decne.	Herb	Green
Lecanthus wallichii Wedd.	Herb	Pink
Lecanthus wightii Wedd.	Herb	Pink
Pilea scripta Wedd.	Herb	Green
Pilea umbrosa Wedd.	Herb	Green
Parietaria debilis Forst.	Herb	Green

VIOLACEAE

Viola canescens Wall. (Banefsha)	Herb	Liliac

VITACEAE

Vitis capreolata D.Don. (Bhinana)	Climbing Shrub	Yellow green

Plants flowering in the month of September

ACANTHACEAE

Barleria cristata Linn.	Herb	Liliac pink
Dicliptera bupleuroides Nees.	Herb	Pink
Justicia simplex Don.	Herb	Pale purple
Strobilanthes alatus Nees.	Shrub	Blue
Strobilanthes Dalhousianus C.B. Clark	Shrub	Blue

AMARANTACEAE

Achyranthes aspera Linn. (Chirchita)	Shrub	Green pink
Achyranthes bidentata Blume.	Shrub	Green purple
Celosia argentea Linn. (Sufed murg ka phul)	Herb	White
Cyathula tomentosa Moq. (Litchkura)	Shrub	White

APOCYNACEAE

Vinca major	Herb	Pink

ARALIACEAE

Hedera nepalensis Koch. (Mithiari) syn. *Hedera helix* Linn.	Climbing Shrub	Yellow green

BEGONIACEAE

Bigonia amoena Wall.	Herb	Pale pink
Bigonia picta Smith.	Herb	Pale pink

BORAGINACEAE

Cynoglossum furcatum Wall.	Herb	Pale blue
Cynoglossum wallichii G. Don. syn. *Cynoglossum denticulatum*	Herb	Blue

CAMPANULACEAE

Campanula colorata Wall.	Herb	Pale liliac

CAPRIFOLIACEAE

Viburnum coriaceum Blume (Tita, Titmulia)	Tree	White

CARYOPHYLLACEAE

Cerastium vulgatum Linn.	Herb	White
Lychnis fimbriata Wall.	Herb	White creamish
Lychnis nutans Benth	Herb	Purple
Silene faconeriana Royle	Herb	Green yellow

CHENOPODIACEAE

Chenopodium album Linn.	Herb	Green

CRUCIFERAE

Capsella Bursa-pastoris Medic.	Herb	White
Nasturtium montanum Wall	Herb	Yellow
Nasturtium officinale R.Br.	Herb	White

COMPOSITAE

Aster asperculus Nees.	Herb	Purple
Aster molliusculus Wall.	Herb	Liliac
Anaphalis adnata DC.	Herb	White
Anaphalis araneosa DC.	Herb	White
Anaphalis cinnamomea C.B. Clarke	Herb	White
Anaphalis contorta Hook f.	Herb	White
Anaphalis triplinervis C.B. Clarke	Herb	White
Artemisia nilgrica Pam. (Kunj) syn. *Artemisia vulgaris*	Herb	Green
Artemisia parviflora Roxb.	Herb	Green yellow
Artemisia vestita Wall	Herb	Green yellow
Bidens pilosa Linn.	Herb	Yellow white
Bidens wallichii DC.	Herb	Yellow
Carduus nutans Linn.	Herb	Red
Carpesium cernuum Linn.	Herb	Yellow
Echinops cornigerus DC.	Herb	White pale blue
Echinops niveus Wall.	Herb	White pale blue
Erigeron multicaulis DC.	Herb	Pale purple
Erigeron multiradiatus Benth.	Herb	Pale purple
Erigeron linifolius Willd.	Herb	Yellow white purple
Galinsoga parviflora Cav.	Herb	White yellow
Gerbera gossypiana Royle	Herb	Pink
Gnaphalium hypoleucum DC.	Herb	Yellow
Inula cappa DC.	Herb	Yellow
Inula cuspidata C.B. Clarke	Herb	Yellow
Lactuca hastata DC.	Herb	Blue
Lactuca macrorhiza Hook. f.	Herb	Grey blue
Siegesbeckia orientalis Linn.	Herb	Yellow white
Solidago virga-aurea Linn.	Herb	Yellow
Sonchus arvensis Linn.	Herb	Yellow

Sonchus oleraceous Linn. var. *asper*	Herb	Yellow
Senecio chrysanthemoides DC.	Herb	Yellow
Senecio rufinervis DC.	Herb	Yellow
Taraxacum officinale Wigg. var. *criopoda*	Herb	Yellow
Tragopogon gracile Don.	Herb	Yellow
Vernonia cinera Less.	Herb	Purple

COMMELINACEAE

Cyanotis barbata Don.	Herb	Blue

CONVOLVULACEAE

Ipomaea purpurea Lam.	Twining Herb	pink

CRASSULACEAE

Sedum linearifolium Royle	Herb	White
Sedum trifidum Wall.	Herb	Pink
Tillaea pentandra Royle.	Herb	Pink white

CRUCIFERAE

Capsella Bursa-pastoris Medic.	Herb	White
Nasturtium montanum Wall.	Herb	Yellow
Nasturtium officinale R.Br.	Herb	White

CYPERACEAE

Eriophorum cosmosum Wall.	Herb	White

DIPSACARCEAE

Dipsacus inermis Wall	Herb	White

DROSERACEAE

Drosera lunata Buch-Ham (Mukha-jali)	Herb	White

EUPHORBIACEAE

Acalypha brachystachya Hornem.	Herb	Green
Andrachne cordifolia Muell. & Arg. (Bhatula)	Shrub	Green

FUMARIACEAE

Corydalis cornuta Royle.	Herb	Yellow

GENTIANACEAE

Gentiana capitata Buch-Ham.	Herb	Blue
Gentiana contorta Royle	Herb	Blue
Swertia Chirata Buch-Ham. (Chirayata)	Herb	Green yellow purple
Swertia cordata Wall.	Herb	Yellow green
Swertia paniculata Wall.	Herb	White
Swertia pursurescens Wall.	Herb	Purple
Swertiate tragona C.B. Clarke	Herb	White

GERANIACEAE

Geranium nepalense Sweet	Herb	Blue purple
Geranium wallichianum Sweet	Herb	Pale Purple
Impatiens amphorata Edgew	Herb	Purple
Impatiens racemosa DC. var. *eclarata*	Herb	Yellow
Impatiens scabrida DC.	Herb	Yellow
Oxalis corniculata Linn. (Tipatia)	Herb	Yellow

GESNERACEAE

Platystemma violoides Wall	Herb	Blue

HYPERICACEAE

Hypericum elodeoides Choisy (Piunli)	Herb	Yellow
Hypericum patulum Thunb	Herb	Yellow
Hypericum perforatum Linn.	Herb	Yellow

HYDROCHARIDEAE

Hydrilla verticillata	Herb	Aquatic

JUNCACEAE

Juncus glaucus Ehrh.	Herb	White brown
Juncus prismatocarpus R.Br.	Herb	Whiteb rown

LABIATAE

Ajuga bracteosa Wall	Herb	Liliac
Calamintha umbrosa Benth	Herb	Pink purple
Colquhounia coccinea var. *mollis* (Pothi)	Shrub	Red
Craniotome versicolor Reichb.	Herb	White pink
Elsholtzia polystachya Benth.	Shrub	White
Lamium album Linn.	Herb	White pink
Leucas cephalotes Spreng.	Herb	White
Leucas lanata Benth.	Herb	White
Micromeria biflora Benth.	Herb	Pink
Nepeta distans Benth.	Herb	Pale pink
Nepeta elliptica Royle	Herb	Pale blue
Nepeta leucophylla Benth.	Herb	Liliac
Nepeta spicata Benth.	Herb	Pale pink
Parochetus communis Buch-Ham.	Herb	Violet blue
Plectranthus coetsa Buch-ham	Herb	Lavender blue
Plectranthus Gerardianus Benth.	Herb	White
Plectranthus rugosus Wall. (Kurkha)	Herb	White
Salvia glutinosa Linn.	Herb	Purple
Scutellaria grossa Wall.	Shrub	Blue
Stachys sericea Wall.	Herb	Pale purple
Teucrium quadrifarium Buch-Ham	Herb	Pink purple

LEGUMINOSAE

Astragalus chlorostachys Lindl.	Shrub	Pale yellow green
Atylosia platycarpa Benth.	Herb	Yellow
Crotalaria sericea Retz.	Herb	Yellow
Desmodium concinnum DC.	Shrub	Blue

Desmodium floribundum G.Don.	Shrub	Pink purple	
Desmodium tiliaefolium Don. (Chamlai)	Shrub	Pale pink	
Flegmingia vestita Benth.	Shrub	Red	
Medicago falcata Linn.	Herb	Yellow	
Melilotus alba Lam.	Herb	Yellow	
Moghania strobilifera	Shrub	Pink white	
syn. *Flemingia strobilifera*			
syn. *Flemingia fructiculosa* Wall.			
Trigonella gracilis Benth.	Herb	Yellow	
Trigonella pubescens Edgew.	Herb	Yellow	
Vicia rigidula Royle.	Herb	Purple blue	

LORANTHACEAE

Loranthus cordifolius Wall.	Parasitic	Shrub
Loranthus vestitus Wall.	Parasitic	Shrub

MALVACEAE

Malva verticillata Linn.	Herb	Pale pink

MELASTOMACEAE

Osbeckia stellata Wall.	Shrub	Pink	330

MENISPERMACEAE

Stephania elegans Hook. f. & Thomas	Climbing Shrub	Red purple

NAIDACEAE

Najas major Allioni	Herb	Aquatic
Potamogeton pectinatus Linn.	Herb	Aquatic
Potamogeton perfoliatus Linn.	Herb	Aquatic

OLEACEAE

Jasminum grandiflorum Linn. (Chameli) Climbing	Shrub	White
Jasminum humile Linn. (Pili-chameli)	Shrub	Yellow

ONAGRACEAE

Satyrium nepalense Don. (Masal-misri)	Herb	Pink
Spiranthes australis Lindl.	Herb	Pink

PLANTAGINAGEAE

Plantago major Linn.	Herb	Green

POLYGONACEAE

Fagopyrum cymosum Meissn. (Ban ogal)	Herb	White
Fagopyrum esculentum Moench. (Ogal)	Herb	White
Polygonum alatum Buch-Ham.	Herb	White
Polygonum amplexicaule Don. var. *speciosa*	Herb	White
Polygonum amphibium Aquatic	Herb	Red
Polygonum chinense Linn. (Ameta)	Herb	White pink
var. *corymbosa*		
var. *ovalifolia*		
Polygonum polystachyum Wall.	Herb	Green pink

Polygonum pterocarpum Wall.	Herb	Green pink
Polygonum sagittatum Linn.	Herb	Pink
Rumex hastatus Don. (Almora)	Herb	Green
Rumex nepalensis Spreng.	Herb	Green
Rumex orientalis Bernh.	Herb	Green

RANUNCULACEAE

Anemone vitifolia Buch-Ham.	Herb	White
Clematis Buchananiana DC.	Climbing Shrub	Yellow white
Ranunculus diffusus DC.	Herb	Yellow
Ranunculus laetus Wall.	Herb	Yellow

ROSACEAE

Agrimonia Eupatorium Linn.	Herb	Yellow
Potentilla fulgens Wall.	Herb	Orange yellow
Potentilla Kleiniana Wight & Arn.	Herb	Yellow
Potentilla nepalensis Hook.	Herb	Red
Prinsepia utilis Royle (Bhekal)	Shrub	White
Spiraea canescens Don. (Miaral)	Shrub	White

RUBIACEAE

Anotis calycina Wall.	Herb	White liliac
Galium acutum Edgew	Herb	White
Galium asperifolium Wall.	Herb	Red
Galium rotundifolium Linn.	Herb	White green
Leptodermis lanceolata Wall. (Padhera)	Shrub	White purple
Rubia cordifolia Linn. (Majitha)	Climber	Red

RUTACEAE

Boenninghausenia albiflora Reichenb. (Pissumar)	Herb	White

SAXIFRAGACEAE

Parnassia nubicola Wall.	Herb	White
Saxifraga Brunoniana Wall.	Herb	Yellow

SCITAMINEAE

Hedychium spicatum (Haldu, Kapurkachri) syn. *Hedychium acuminatum* Wall.	Herb	White orange
Roscoea procera Wall	Herb	Liliac

SCROPHULARIACEAE

Lindenbergia grandiflora Benth.	Herb	Yellow
Mazus rugosus Lour.	Herb	Pale blue white
Pedicularis pectinata Wall.	Herb	Pink
Sopubia trifida Buch-Ham.	Herb	Yellow
Verbascum thapsus Linn. (Gidar tambaku)	Herb	Yellow
Wulfenia Amherstiana Benth.	Herb	Blue purple

SOLANACEAE

Datura stramonium Linn. (Dhatura)	Herb	White
Nicandra physaloides Gaertn.	Herb	Blue
Solanum nigrum Linn. (Makoi)	Herb	White

THYMELAEACEAE

Daphne papyraceae Decne (Satpura)	Shrub	White liliac
Wikstroemia canescens Meissn.	Shrub	Yellow

UMBELLIFERAE

Bupleurum Candollii Wall.	Herb	Yellow
Bupleurum falcatum Linn. var. *marginatum*	Herb	Yellow
Heracleum canescens Lindl.	Herb	White
Pimpinella acuminata C.B. Clarke	Herb	White
Pimpinella diversifolia DC.	Herb	White
Selinum tenuifolium Wall.	Herb	White

URTICACEAE

Cannabis sativa Linn. (Bhang)	Herb	Yellow green
Elatostema sessile Forst. var. *cuspidata*	Herb	Green
Girardiana heterophylla Decne. (Bitchu Ghass)	Herb	Green
Lecanthus wightii Wedd.	Herb	Pink
Parietaria debilis Forst.	Herb	Green
Pilea scripta Wedd.	Herb	Green
Pilea umbrosa Wedd.	Herb	Green
Urtica parviflora Roxb.	Herb	Green

VERBENACEAE

Phryma leptostachya Linn.	Herb	Pale pink

VITACEAE

Vitis capreolata D. Don. (Bhinana) syn. *Tetrastigma serrulata*	Climbing Shrub	Yellow green

Plants flowering in the month of October

ACANTHACEAE

Barleria cristata Linn.	Herb	Liliac pink
Dicliptera bupleuroides Nees.	Herb	Pink
Justicia simplex Don.	Herb	Pale purple
Strobilanthes Dalhousianus C.B. Clarke	Herb	Blue
Strobilanthes alatus Nees.	Shrub	Blue

Amarantaceae

Achyranthes aspera Linn. (Chirchita)	Shrub	Green purple
Achyranthes bidentata Blume var. *porphyristachya*	Shrub	Green purple
Celosia argentea Linn.	Herb	White
Cyathula tomentosa Moq. (Litch-kura)	Shrub	White

Araliaceae

Hedera nepalensis Koch. (Mathiari) syn. *Hedera helix* Linn.	Climbing Shrub	Yellow green

Boraginaceae

Cynoglossum wallichii G. Don. syn. *Cynoglossum denticulatum* DC.	Herb	Blue

Campanulaceae

Campanula colorata Wall.	Herb	Pale liliac

Caryophyllaceae

Lychnis fimbriata Wall.	Herb	White creamish
Lychnis nutans Benth.	Herb	Purple

Chenopodiaceae

Chenopodium album Linn.	Herb	Green

Compositae

Aster asperculus Nees.	Herb	Purple
Achillea millefolium Roxb.	Herb	Green Yellow
Artemisia nigrica Pam. syn. *Artemisia vulgaris* Linn.	Herb	Green
Artemisia parviflora Roxb	Herb	Green
Artemisia vestita Wall.	Herb	Green yellow
Bidens pilosa Linn.	Herb	Yellow white
Carduus nutans Linn.	Herb	Red
Carpesium cernuum Linn.	Herb	Yellow
Erigeron multicaulis DC. var. *semibarbata* var. *obovatus*	Herb	Pale purple
Erigeron multiradiatus Benth.	Herb	Pale purple
Gnaphalium hypoleucum DC.	Herb	Yellow
Galinsoga parviflora Cav.	Herb	White yellow
Gerbera gassypiana Royle	Herb	Pink
Inula cappa DC.	Herb	Yellow
Inula cuspidata C.B. Clarke	Herb	Yellow
Lactuca hastata DC.	Herb	Dark Blue
Myriactis wallichii Less.	Herb	Yellow.
Siegesbeckia orientalis Linn.	Herb	Yellow
Sonchus arvensis Linn.	Herb	Yellow
Sonchus oleraceous Linn. var. *asper*	Herb	Yellow
Solidago virga-aurea Linn.	Herb	Yellow
Taraxacum officinale Wigg. var. *eriopoda*	Herb	Yellow
Tragopogon gracile Don.	Herb	Yellow

	COMMELINACEAE	
Cyanotis barbata Don.	Herb	Blue
	CONVOLVULACEAE	
Ipomoea purpurea Lam.	Twining herb	Pink
	CRUCIFFRAE	
Capsella Bursa-pastoris Medic.	Herb	Yellow
	CUPULIFERAE	
Alnus nepalensis Don. (Utis, Us)	Tree	Green
	CYPERACEAE	
Eriophorum cosmosum Wall.	Herb	Brown
	DIPSACACEAE	
Dipsacus inermis Wall.	Herb	White
	EUPHORBIACEAE	
Acalypha brachystachya Hornem.	Herb	Green
	GENTIANACEAE	
Gentiana contorta Royle	Herb	Blue
Swertia chirata Buch-Ham (Chirayta)	Herb	Green purple
Swertia paniculata Wall.	Herb	White
Swertia tetragona C.B. Clarke	Herb	White
	GERANIACEAE	
Impatiens amphorata Edgew	Herb	Purple
Oxalis corniculata Linn (Tipatia)	Herb	Yellow
	HYPERICACEAE	
Hypericum patulum Thunb.	Herb	Yellow
Hypericum perforatum Linn.	Herb	Yellow
	LABIATAE	
Ajuga bracteosa Wall.	Herb	Liliac
Craniotome versicolor Reichb.	Herb	White pink
Lamium album Linn.	Herb	White pink
Leucas lanata Benth	Herb	White
Micromeria biflora Benth.	Herb	Pink
Nepeta cilliaris Benth.	Herb	Purple blue
Nepeta distans Benth.	Herb	Pale pink
Nepeta elliptica Royle	Herb	Pale blue
Nepeta leucophylla Benth.	Herb	Liliac
Plectranthus coetsa Buch-Ham.(Molchera)	Herb	White
Plectranthus Gerardianus Benth.	Herb	White
Plectranthus rugosus Wall. (Kurkha)	Herb	White
Plectranthus striatus Benth.	Herb	White
Salvia glutinosa Linn.	Herb	Yellow purple
Salvia grossa Wall.	Shrub	Blue

Scutellaria grossa Wall.	Herb	Pink purple
Stachys sericea Wall.	Herb	Pink
Teucrium quadrifarum Buch-Ham.	Herb	Purple pink

LEGUMINOSAE

Desmodium tiliaefolium Don. (chamlai)	Shrub	Pale pink
Flemingia fructiculosa Wall.	Shrub	Pink white
Trigonella gracilis Benth.	Herb	Yellow

LORANTHACEAE

Loranthus cordifolius Wall. (Bana)	Parasitic shrub	
Loranthus vestitus Wall.	Parasitic shrub on Quercus incana Roxb.	

MAGNOLIACEAE

Michelia champaca (Champa)	Tree	Yellow

OLEACEAE

Jasminum Humile Linn. (Pili-chameli)	Shrub	Yellow

ONAGRACEAE

Epilobium hirsutum Linn.	Herb	Pink purple
Oenothera rosea Sol.	Herb	Pink

ORCHIDACEAE

Satyrium nepalense Don. (Masal-misri)	Herb	Pink

PLANTAGINACEAE

Plantago major Linn.	Herb	Green

POLYGONACEAE

Polygonum alatum Buch-Ham.	Herb	White
Polygonum amplexicaule Don. var. *speciosa.*	Herb	Red
Polygonum chinense Linn. (Ameta)	Herb	White pink
Polygonum polystachyum Wall.	Shrub	White pink
Polygonum pterocarpum Wall	Herb	Green pink
Polygonum recumbens Royle	Herb	Pink
Polygonum sagittatum Linn.	Herb	Pink

POLYGALACEAE

Polygala crotalarioides Buch-Ham.	Herb	Purple

ROSACEAE

Prinsepia utilis Royle. (Bhekal)	Shrub	White
Potentilla Kleiniana Wight & Arn.	Herb	Yellow

RUBIACEAE

Galium acutum Edgew	Herb	White
Hamiltonia Suaveolens Roxb.	Shrub	Blue
Rubia cordifolia Linn. (Majith)	Climbing Herb	Red

SAXIFRAGACEAE

Saxifraga Brunoniana Wall	Herb	Yellow

SCROPHULARIACEAE

Lindenbergia grandiflora Benth.	Herb	Yellow
Mazus rugosus Lour.	Herb	Pale blue white
Veronica agrestis Linn.	Herb	Blue
Veronica biloba Linn.	Herb	Blue
Verbascum thapsus Linn. (Gidar-tambaku)	Herb	Yellow

THYMELAEACEAE

Daphne papyracea Decne. (Satpura)	Shrub	White liliac

UMBELLIFERAE

Ligusticum elatatum C.B. Clarke	Herb	White
Pimpinella acuminata C.B. Clarke	Herb	White
Pimpinella diversifolia DC.	Herb	White
Selinum tenuifolium Wall. var. *elata*	Herb	White

URTICACEAE

Parietaria debilis Forst.	Herb	Green

Plants flowering in the month of November

ACANTHACEAE

Dicliptera bupleuroides Nees	Herb	Pink
Justicia simplex Don.	Herb	Pale purple
Strobilanthes glutinosus Nees	Herb	Pale blue

BORAGINACEAE

Cynoglossum wallichii G. Don.	Herb	Blue

CARYOPHYLLACEAE

Lychnis fimbriata Wall.	Herb	Purple

COMPOSITAE

Taraxacum officinale Wigg. var. *eriopoda*	Herb	Yellow
Tragopogon gracile Don.	Herb	Yellow

CRUCIFERAE

Capsella Bursa-pastoris Medic.	Herb	White

CUPULIFERAE

Alnus nepalensis Don. (Utis, Ust)	Tree	Green

DIPSACACEAE

Dipsacus inermis Wall.	Shrub	White

GENTIANACEAE

Swertia chirata Buch-Ham. (Chirayatta)	Herb	Green purple

	GERANIACEAE	
Oxalis corniculata Linn. (Amelda)	Herb	Yellow
	LEGUMINOSAE	
Shuteria involucrata Wight. & Arn.	Herb	White pink
	LILIACEAE	
Asparagus adscendens Roxb. (Sitawar)	Shrub	White
	LORANTHACEAE	
Loranthus vestitus Wall.	Parasitic Shrub	
	POLYGONACEAE	
Polygonum alatum Buch-Ham (Ameta)	Herb	White
	SOLANCEAE	
Datura stramonium Linn. (Dhatura)	Shrub	White
	THYMELAEACEAE	
Daphne papyracea Decne (Satpura)	Shrub	White purple
	URTICACEAE	
Parietaria debilis Forst.	Herb	Green

Plants flowering in the month of December

	ACANTHACEAE	
Dicliptera bupleuroides Nees.	Herb	Pink
	COMPOSITAE	
Galinsoga parviflora Cav.	Herb	White yellow
	CUPULIFERAE	
Alnus nepalensis Don. (Utis, Ust)	Tree	Green
	ROSACEAE	
Prinsepia utilis Royle (Bhekal)	Shrub	White
	URTICACEAE	
Parietaria debilis Forst	Herb	Green

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FLORAL BIOLOGY AND CYTOLOGY OF SOME SOLANACEOUS WEEDS OF KANPUR

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In 1928 Vilmorin and Simonet gave a comprehensive account of the chromosome number of species belonging to the family Solanaceae. This was followed by a study of seventeen solanaceous species of Bengal by Bhaduri (1933) who, however, confined himself to a mere mention of the chromosome number. Since then a good deal of work has been done on the cytology of members of this family, the chief genera investigated being *Solanum* and *Nicotiana* (Goodspeed, 1945, 1947; Santapau, 1948; Avanzi, 1949; Brown, 1950 and Margaret, 1950).

The present investigation was undertaken with the idea of knowing the floral biology of some of the solanaceous weeds and also to see if the cytological behaviour of the plants studied is similar to that found elsewhere. The floral biology and the chromosome number of *Solanum nigrum, S. torvum, Physalis minima, Withania somnifera* and *Nicotiana plumbaginifolia* has, therefore, been worked out and the results obtained are presented in this paper.

Material and Methods

The material concerned in this investigation has been studied during 1955-56 at its natural habitat in the campus of the Govt. Agricultural College, Kanpur.

To study the number of days required for the opening of flower, a few bud initials were tagged and labelled. Regular observations, with regard to the blooming time, mechanism of blooming, total number of days required for blooming, were noted and tabulated. Dehiscence of anthers was noted with the help of a hand lens and their relation to the maturity of stigma found out, the latter being marked by the stigmatic secretion.

Fixations of young buds for cytological study was done at the spot in Acetic Alcohol (1 part acetic acid + 3 parts absolute alcohol). Meiosis was studied in temporary acetocarmine squash preparations. Drawings were made at bench level with the help of a Spencer camera lucida.

Observations

1. *Solanum nigrum Linn.*

Floral biology: (Figs. 1, 2). A bud in initial stages remains enclosed within the calyx teeth. Three to four days are required for it to develop externally visible corolla through the calyx teeth. Thereafter, 7-8 days are needed for the opening of flower. Soon after opening anthers begin to dehisce through the apical pores. At this stage the filaments slightly elongate while the stigma remains well below the level of anthers. The style then gradually elongates and the stigma surpasses the level of anther tips. The secretion of stigmatic fluid at this stage indicates the maturity of the pistil.

Maximum blooming period lies between 4.30 to 5.00 A.M. Basal flowers are the first to open. In no case more than 2-3 flowers are found open on the same inflorescence the same day. The entire inflorescence takes about 2-5 days to finish blooming. Third day after opening, the corolla tube closes and ultimately fades up and falls off along with the shrivelled anthers.

Eight to twenty-four hours are required for the pollen tube to traverse the length of the style and affect fertilization. The total time required between pollination and maturity of fruit ranges between 38-42 days. Observational findings reveal that self pollination is the rule.

Cytology (Figs. 3—10): The meiotic chromosome number in the polar view of Metaphase I is found to be 36. A similar number is observed at diakineses and at Metaphase II. At diakinesis various configurations of chromosomes are visible. They may be rod shaped, ring shaped, V-shaped and X-shaped, out of which rings and rods are of frequent occurrence. At the onset of Metaphase I the chromosomes become markedly reduced in size, nucleolus disappears and metaphase plate is laid down. At Metaphase II the two metaphase plates are laid down side by side. No cell wall formation and interkinesis is marked out between the two sister cells. A perfect synchronisation is found in the movement of four groups. Isobilateral tetrads of microspores are formed and cytokinesis takes place by furrowing.

2. **Solanum torvum** Swartz

Floral biology (Figs. 11, 12): Numerous fiowers are borne on an extra-axillary cyme. Blooming occurs in acropetal succession. Normally 2-3 flowers open on the same inflorescence the same day but their number may go up to 5-6 per day. From the time of the floral bud initiation 5-6 days are required for the corolla to become externally visible. Twenty to Twenty-one days in all are sufficient for blooming.

Maximum blooming occurs between 5.00-5.30 A.M. The first sign is shown by the bud soon after midnight and within three hours the corolla is found fully stretched. The time of anther dehiscence and maturity of stigma are concurrent. Both mature half an hour after blooming. Flowers opened in the morning remain open for three continuous days (about 72 hours). They gradually begin to close towards the later half of the third day and the corolla finally fades away the fourth day.

Self pollination is the rule and about 30-36 hours are required from pollination to fertilization. Total time required from the day of pollination to maturity of fruit is 67-68 days. The mature berries remain attached to the plant for a longer time.

The percentage of fruit setting is only 25-30. The fruits set are greatly damaged by insect larvae. This may be one of the causes of its slow distribution. It is only the few basal flowers that are destined to develop into fruits while all others fall away.

Cytology (Figs. 13-22): Haploid number of chromosomes, found at different stages of meiotic division, is 12 (cf. Bhaduri, 1933). During meiosis I the spindles are broad in the middle and end bluntly at the periphery of the microspore mother cell. The unequal pull at the two group ends gives it a characteristic V-shaped structure at Anaphase I. Varying number of chromatid bridges are also found at the proximal ends, which may account for such behaviour of spindles. Once the break occurs in the chromatid bridge, the spindles begin to straighten and ultimately, at late anaphase, they are found comparatively straight. Telophase is normal and no interkinesis is envolved.

At Metaphase II the plates are found oriented at right angles or side by side, parallel to each other. Unlike meiosis I the spindles are straight, normal and sharply pointed. Later divisions are found to occur with mechanical regularity. Microspore tetrads are arranged in tetrahedral or isobilateral fashion. Cytokinesis occurs by furrowing.

Chromosome dyads at diakinesis, arranged in a line, show a characteristic uniformity in their size and no marked difference in their structure can be attributed.

3. **Physalis minima** Linn

Floral biology (Figs. 23, 24): Solitary flowers are borne in the axil of leaves. Generally only one flower opens every day on the same branch. Two days after the initiation of flower buds, corolla becomes visible in-between the calyx teeth. The flower bud opens on the sixth or seventh day. Maximum blooming occurs between 5·00-5·30 P.M. Dehiscence of a group of three anthers starts in the evening and finishes by the time blooming starts. Anther group of two smaller anthers dehisces the next morning and finishes by 9 A. M. Stigma matures at the blooming hours.

Corolla begins to show signs of closing at 12 noon next day and by about 5 P. M., i. e, 24 hours after opening, it completely closes. Next day, i.e. on the third day after blooming it gets detached along with epipetalous stamens- The calyx now grows vigourously, covers the gynaecium completely and continues to grow along with the fruit.

Self pollination is the rule. The total time required from pollination to maturity of fruit is 12-15 days. The fruit matures and gets detached from the branch 36th to 37th day aftet flower opening.

Cytology (Figs. 25-30): Haploid chromosome number, as fouud at different countable stages of meiotic division, is 24 (cf. Bhaduri, 1933). Secondary synapsis is noticed in some pairs of chromosomal dyads (indicated by arrow marks in Fig. 25). Different configurations are found at this stage, of which rods are most common. Rings are less frequent in occurrence.

Spindles at Metaphase I are sharply pointed and broad at the middle. No interkinesis is envolved. At Metaphase II plates are laid down side by side and synchronised movement of genomes is noticed. Tetrads of microspores are isobilateral and cytokinesis occurs by furrowing.

4. **Withnia somnifera** Dunal.

Floral biology (Figs. 31-32): Ten to fifteen flowers are borne on the axillary raceme. Blooming starts in acropetal succession. Ordinarily 1 to 2 flowers are found open each day on the same axis. However, in favourable conditions their number may go up to 4. Marked delay in flowering is seen on cloudy days. After 5-6 days of initiation of floral bud, the lurid yellow corolla becomes externally visible in-between the calyx teeth, and blooming occurs 6 days thereafter. A fully developed bud starts opening at about 5 A.M. and completes the process within 1—1½ hours. In this way maximum blooming occurs between 6.00-6. 30 A. M.

First sign of opening is indicated by a gradual separation of corolla lobes. Their folds, along with the calyx teeth, also get separated. A fully open corolla is hardly seen above the level of calyx teeth and can be marked out only by closer observations.

Dehiscene of anthers occurs in succession of one by one. Twelve hours prior to the opening of flower, the largest anther begins to dehisce and within three hours the other two bigger ones also finish their dehiscence. The remaining two smaller ones do not dehisce till the early hours of next morning. Their dehiscence, thus, occurs half hour after blooming. The stigma also matures at this time.

Flowers opened in the morning remain so throughout the day and subsequent night. Next day they begin to close and show signs of fading. Third day after opening, i. e. 48 – 60 hours afterwards the corolla along with stamens gets detached. The stigma, however, remains attached to the ovary for two more days.

Self pollination is the rule. Total time required from pollination to fertilization is 24 to 27 hours. Five to Seven days are required for the entire inflorescence to finish blooming. Time taken between opening of flower to maturity of fruit varies between 48—52 days. However, berries are found pe.sisting longer on the plant. The percentage of fruit setting is cent percent.

Cytology (Figs. 33 – 38): Haploid number of chromosomes, counted at various stages of meiotic division, is 24 (Cf. Bhaduri, 1933). At early diakinesis one nucleolus and dyads of varying sizes are noticed. Various types of configurations are met with, rods and ring being more common.

At late diakinesis a marked reduction in the size of the components is noticed. At this stage also they are markedly differentiated into various size groups. At Metaphase I the spindles are unequal. No interkinesis is found to intervene.

At Metaphase II the plates are laid down side by side and a complete homogeneity in movements of genomes is noted at Anaphase II. Isobilateral tetrads of microspores are produced and cytokinesis takes place by furrowing.

5. **Nicotiana plumbaginifolia Viv.**

Floral biology (Figs. 39, 40): Twenty to twenty-five flower buds are borne on the axillary raceme. At first the bud development is very slow. The greenish corolla becomes visible above the calyx tube within 4—5 days from the time the initial bud makes its appearance. Ten to eleven days after this the bud becomes ready to bloom. On the whole 16-17 days are required for complete blooming.

The first sign of blooming is marked by a gradual separation of corolla lobes at about 5 A. M. By 7.30 to 8 A. M. the lobes become completely stretched and blooming occurs. It is, however, noted that cloudy days shorten their opening time and flowers are found fully opened at early hours of afternoon. Open flowers remain as such throughout the night. They begin to close next morning and by 9 A. M. they close completely. After this they gradually fade away and fall off.

The anthers dehisce 24 hours before the opening of flowers. The time of maturity of stigma coincides with the blooming hours.

Self pollination is the rule. The time required from pollination to fertilization is 33 to 36 hours. It takes about 34 to 35 days for the fully open flower to develop into a mature fruit. Percentage of fruit setting is cent percent.

Cytology (Figs. 41-47): Early prophase shows a normal chromatin net work containing a single nucleolus. The synapsis is normal, but marked variation in the shape and structure of different dyads is met with at the diakinesis stage. Most of the long dyads are rod-shaped although ring formations are also met with.

Striking reduction in chromosome size is seen at the polar view of Metaphase I. The chromosome number counted at this stage is found to be 10 pairs (cf Ramanujam and Joshi, 1942). In a lateral view of this stage no irregularity is seen. Spindles are slender and long pointed, and a complete synchronisation of heterotypic chromosome groups is found. At Telophase I no wall formation takes place and a marked increase in chromosome size is noted. Soon they get shortened and plates at Metaphase II are rotated at right angles to each other. Check counts were made at this stage. Anaphase II and Telophase II are normal with normal spindle formation and complete synchronisation of genome movements. At the tangential view of Telophase II a third check count was made which confirmed previous observations. Tetrahedral tetrads of microspores are of common occurrence. Wall formation takes place by furrowing.

CONCLUSION

Marked difference in the blooming time of different species, belonging to different genera, has been observed. In *Solanum* and *Withania* flowers show nyctinastic movements, i. e. their opening is governed by succession of day and night, while flowers in *Physalis* are found to be thermostatic, i. e. they remain closed in increased temperature and open as soon as the day temperature falls towards the evening. In *Nicotiana* photonastic movements are found, i. e. they tend to close in increased light and open fully under weak light.

Duration between pollination and fertilization ranges between 12 to 36 hours and fruits get matured within 1 to 2 months' time.

Bhaduri (1933) described three polyploid forms of *Solanum nigrum* in Bengal, having 12 as basic number. He has also perpared a key of their respective morphological characters. Taking into view the morphological criterion, anthers were fixed separately from different plants, but no difference in chromosome number has been noticed, and all of them are found to show 2n—72. It suggests that only the hexaploid from of *Solanum nigrum* is available at Kanpur.

As for the occurrence of rings at diakinesis Jorgenson (1928) attributed it to the formation of tetrasomes. On the other hand Bhaduri (1933) contradicted his view. It the present investigation a marked variation in the number of rings and a regular behaviour of meiotic divisions, support Bhaduri's view and suggest their occurrence to be due to synchronised terminalization of two chiasmata situated in two arms of chromosomes.

The chromosome number 2n—24, found in *Solanum torvum* corresponds with the observations of Bhaduri (1933). However, curved spindles, occurrence of chromatid bridges, unequal pull at two ends of plates, and ultimate straightening of spindle at Anaphase I are points which need further studies in order to arrive at a definite conclusion. Their behaviour may be attributed to spontaneous aberrations in chromsome sets and loop formations at Anaphase I (cf. Nicholas, 1941).

According to Bhaduri (1933) the diploid number of chromosomes in *Physalis minima* is 24. The species prevalent at Kanpur is evidently a tetraploid having 2n—48 chromosomes. Attempts were made to obtain diploid forms for a comparative study but not a single plant turned out to be a diploid.

A chromosome number of 2n—48, found in *Withania somnifera,* corresponds with the findings of Bhaduri (1933), Santapau (1948), Margaret (1950) and Brown (1950). However, the unequal reduction of chromosomes at diakinesis and absence of synchronised movements at Anaphase I suggests an alloploid nature of evolution (cf. Sax, 1935).

Chromosome number in *Nicotiana plumbaginifolia* (2n—20) was, for the first time, reported by Christoff (1928). Later his findings have been confirmed by Bhaduri (1933), Ramanujam and Joshi (1942), Goodspeed (1945) and Margaret (1950). Detailed studies of chromosome behaviour in meiotic stages confirm this number and reveal a marked decrease in their size at diakinesis and again a temporary increase at Telophase.

Similar studies on more weeds are underway in this laboratory and with the completion of that work a general discussion on the cytological behaviour of some of the genera of the Solanaceae, along with measures to control the dissemination of weeds under investigation, based on the results of floral biological studies, will follow.

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EXPLANATION OF FIGURES

Figs. 1—2. *Solanum nigrum*. Fig. 1, twig. Fig. 2, open flower.

Figs. 3—10. *Solanum nigrum*, division stages of microspore mother cell. Fig. 3, early prophase. X 2000. Fig. 4, diakinesis showing different gemini and equal sized chromosomes. X 2000. Fig. 5, same magnified to show dyad structure of chromosomes more clearly. X 3000. Fig. 6, metaphase I in polar view. X 2000. Fig. 7, metaphase I in lateral view; note sharp pointed spindles. X 2000. Fig. 8, metaphase II in polar view. X 2000. Fig. 9, same in lateral view. X 2000. Fig. 10, microspore tetrad; note cytokinesis by furrowing. X 2000.

Figs. 11—12. *Solanum torvum*. Fig. 11, twig. Fig. 12, open flower.

Figs. 13—22. *Solanum torvum*, division stages of microspore mother cell. All X 3000. Fig. 13, diakinesis showing twelve pairs of chromosomes. Fig. 14, metaphase I; note acute curvature in spindles. Figs. 15, 16, early anaphase I; note unequal pull of heterotypic groups and occurrence of chromatid bridges. Fig. 17, late anaphase I; note the straightening tendency of spindles. Fig. 18, telophase I; note absence of separating wall. Fig. 19, metaphase II, plates oriented at right angles to each other. Fig. 20, anaphase II showing plates oriented parallel to each other. Fig. 21, telophase II showing tetrahedral arrangement of tetrads. Fig. 22, chromosomes arranged in a line; note equal size and structure.

Figs. 23–24. *Physalis minima*. Fig. 23, twig. Fig. 24, open flower.

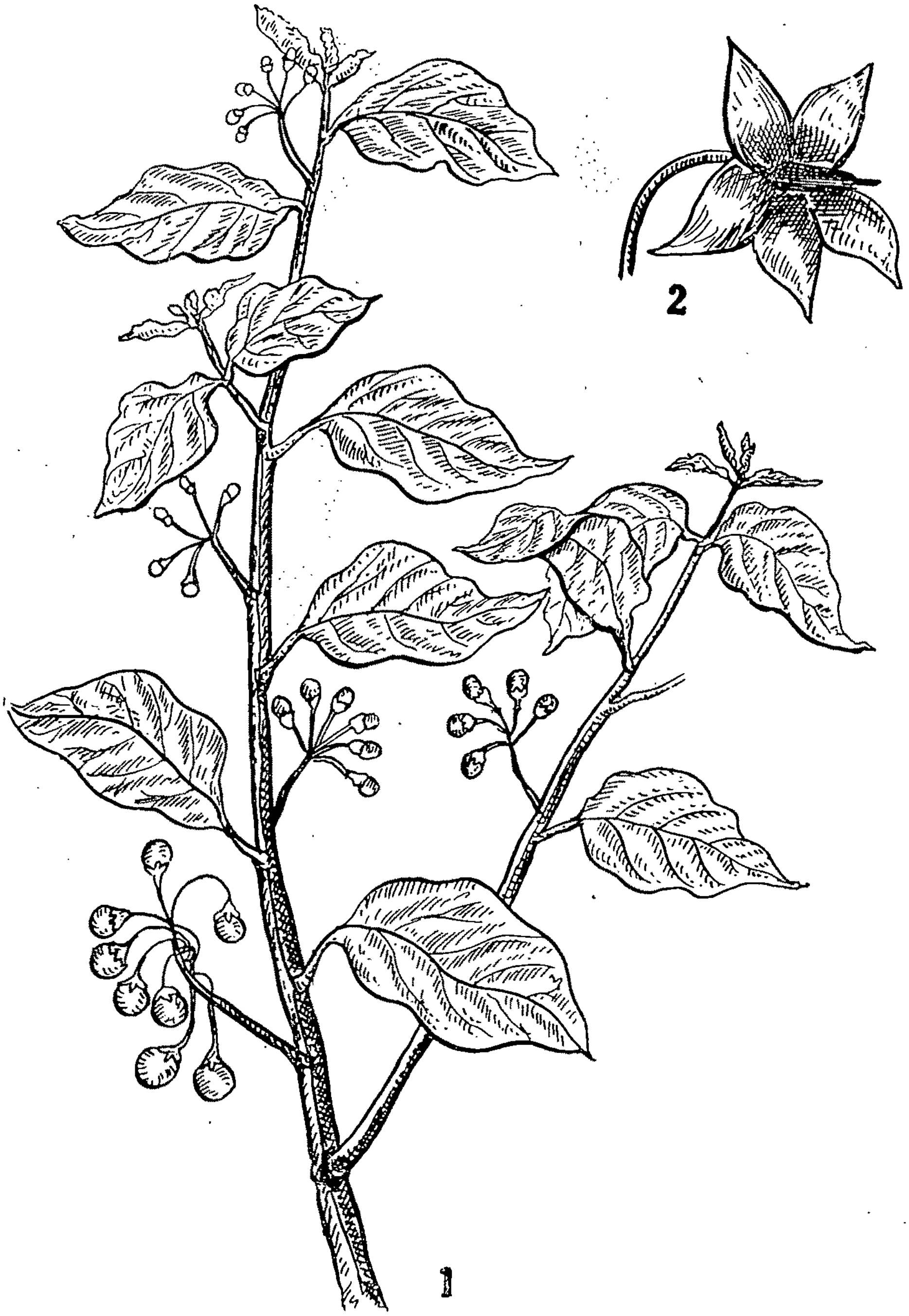
Figs. 25–30. *Physalis minima*, division stages of microspore mother cell. All X 3000. Fig. 25, pachytene stage showing secondary synapsis (shown by arrows) and different gemini formation. Fig. 26. diakinesis; note reduction of chromosome size. Fig. 27, anaphase I. Fig. 28, telophase I; note absence of separating wall. Fig. 29, metaphase II. Fig. 30, telophase II showing isobilateral tetrad of microspores and laying down of basipetal cell plates.

Figs. 31—32. *Withania somnifera*, Fig. 31, twig. Fig. 32, open flower.

Figs. 33—38. *Withania somnifera*, division stages of microspore mother cell. All X 3000. Fig. 33, early diakinesis showing 24 pairs of chromosomes; note variation in size of dyads. Fig. 34, late diakinesis; note marked reduction in size of chromosomes. Fig. 35, anaphase I showing numerous laggards. Fig. 36, telophase I; note absence of separating wall. Fig. 37, anaphase II. Fig. 38, telophase II showing isobilateral tetrad of microspores and furrowing.

Figs. 39—40. *Nicotiana plumbaginifolia*. Fig. 39, twig. Fig. 40, open flower.

Figs. 41—47. *Nicotiana plumbaginifolia* showing division of microspore mother cell. All X 3000. Fig. 41, early diakinesis showing one nucleolus and ten pairs of chromosomes. Fig. 42, metaphase I in polar view; note great reduction in the size of chromosome pairs. Fig. 43, telophase I. Fig. 44, metaphase II. Fig. 45, anaphase II. Fig. 46, tetrahedral tetrad of microspores. Fig. 47, chromosome dyads arranged in a line; note six long and four short pairs.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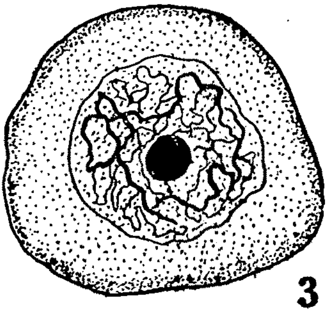

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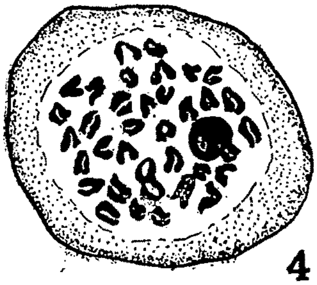

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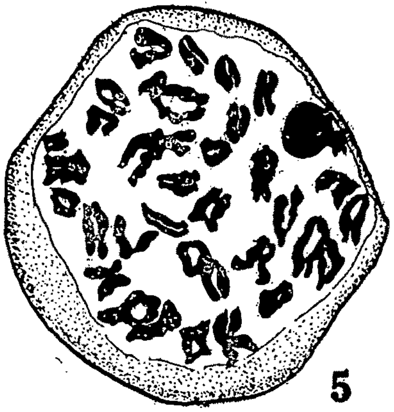

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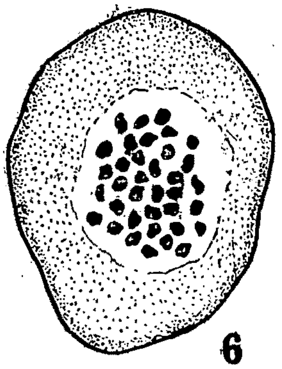

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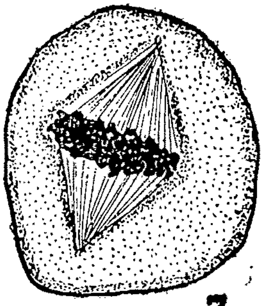

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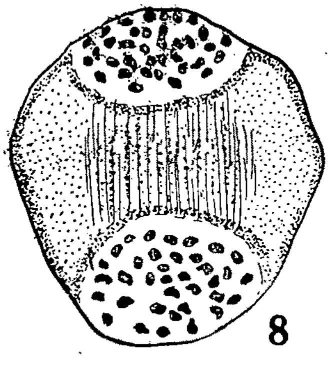

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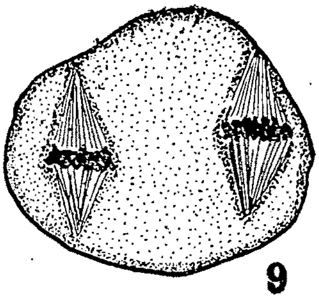

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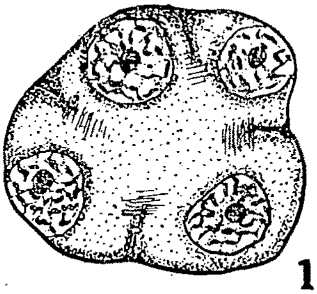

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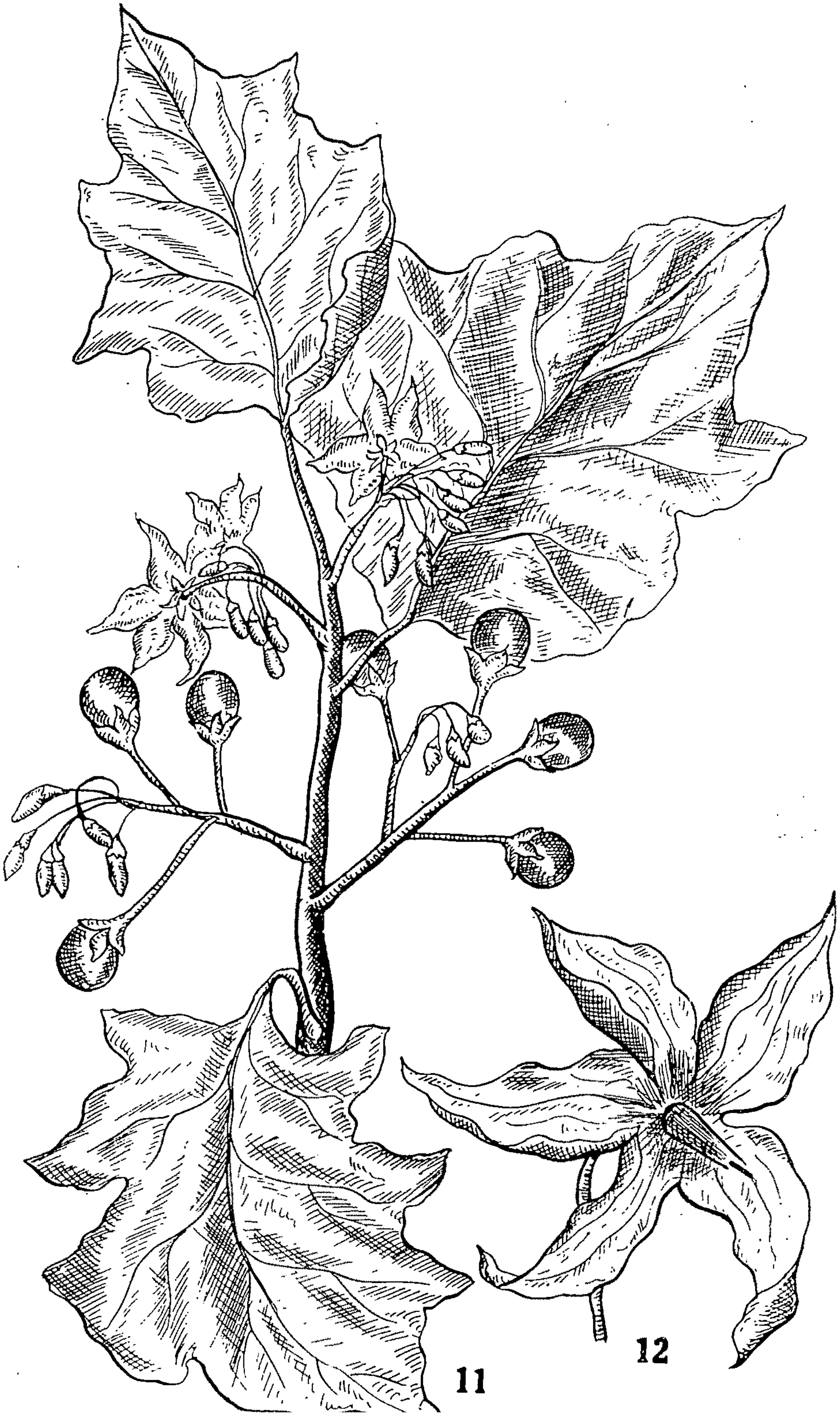

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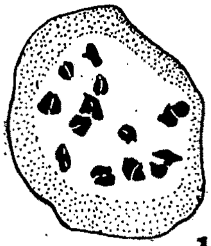
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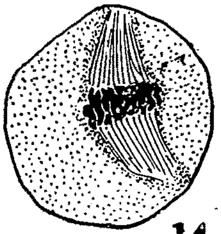
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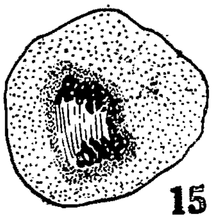
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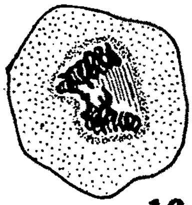
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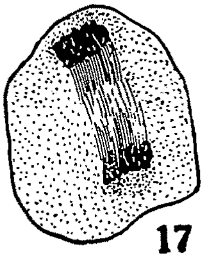
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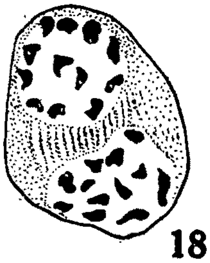
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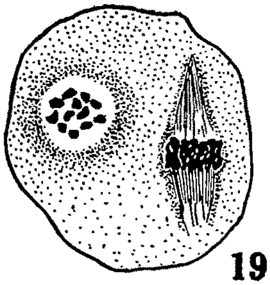
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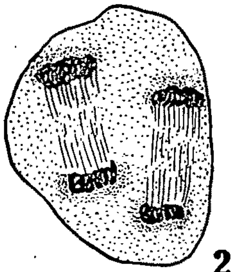
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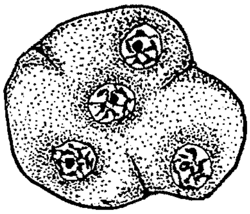
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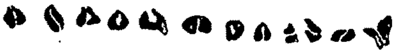
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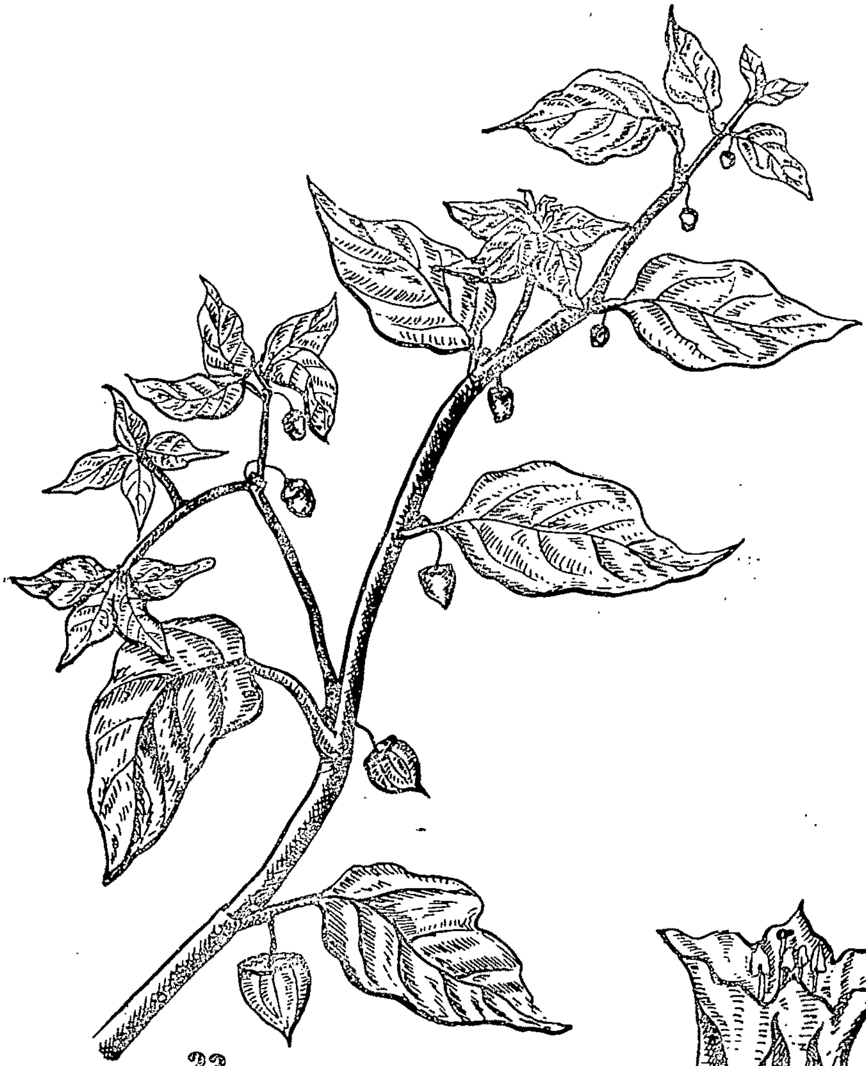

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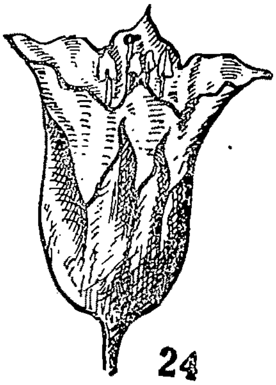

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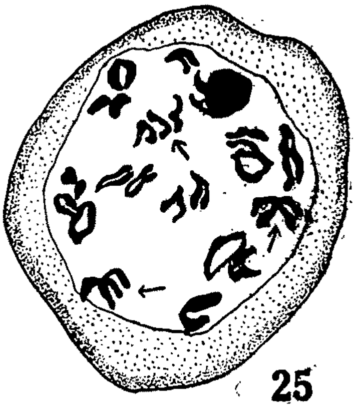

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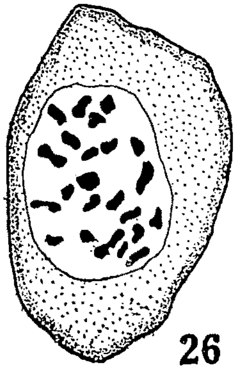

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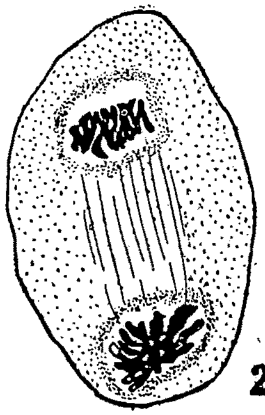

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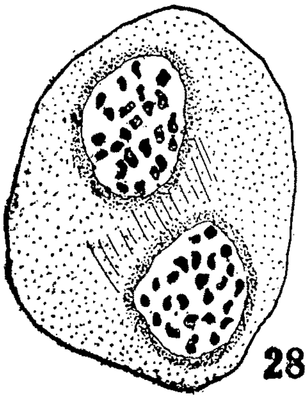

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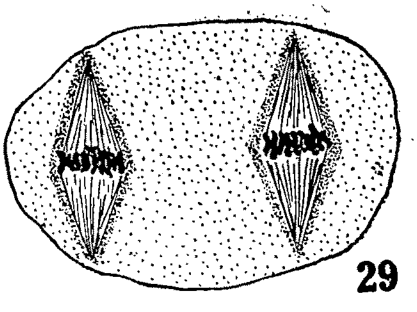

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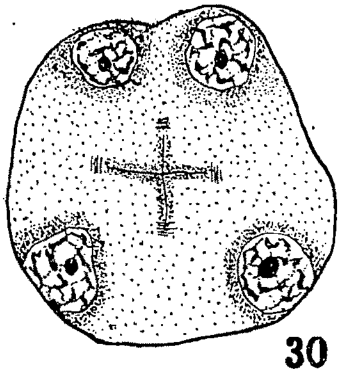

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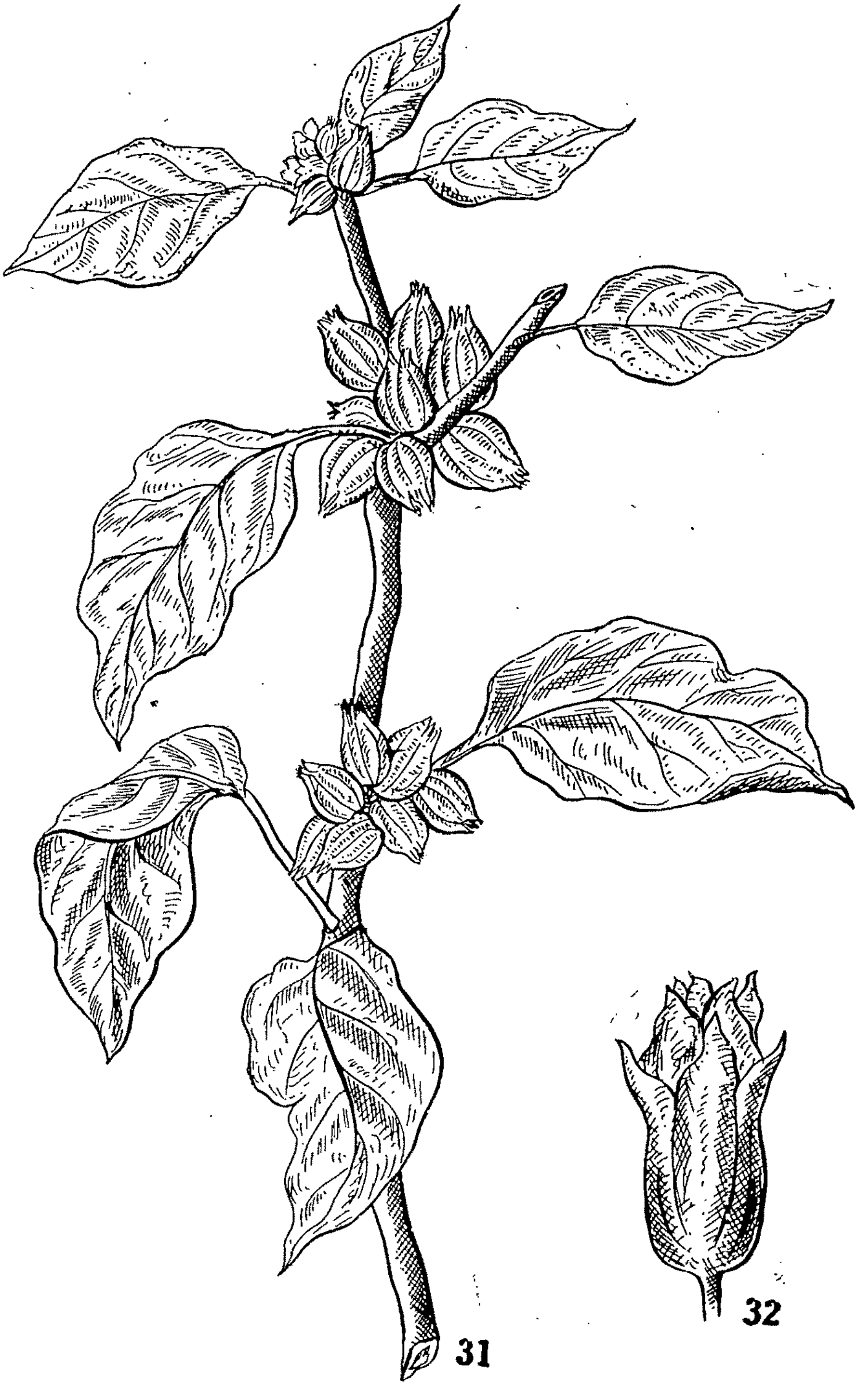

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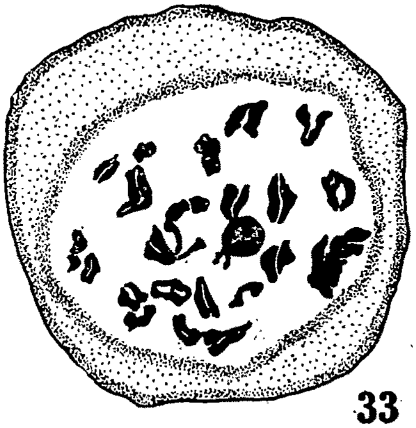
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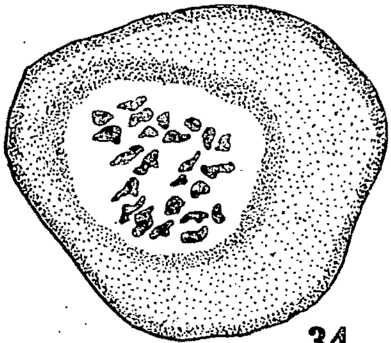
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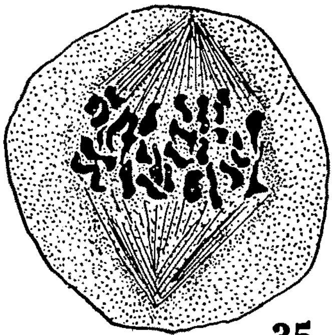
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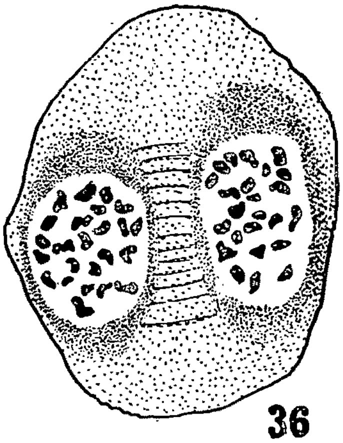
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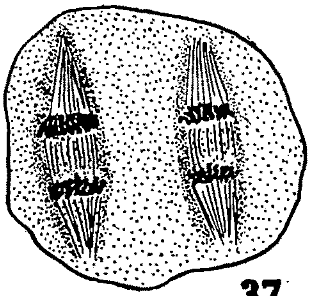
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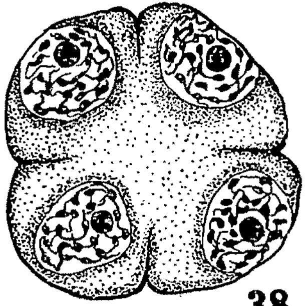
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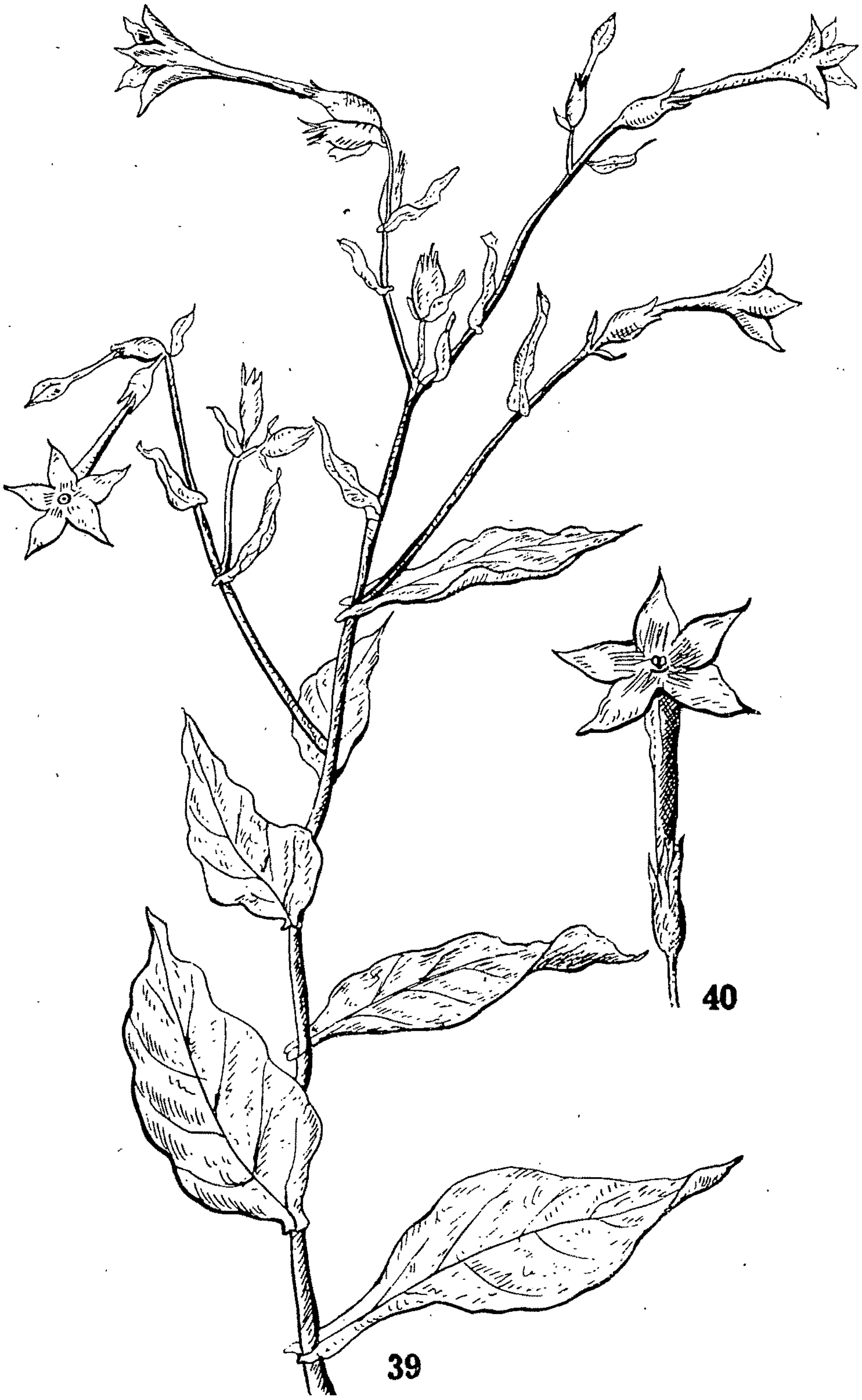

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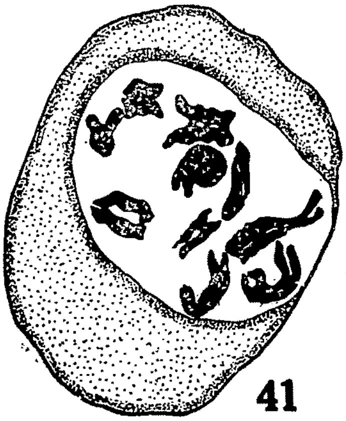

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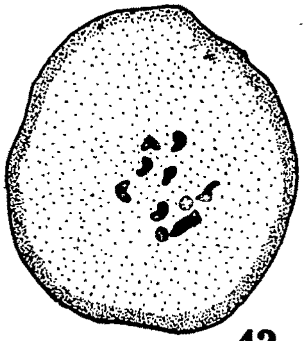

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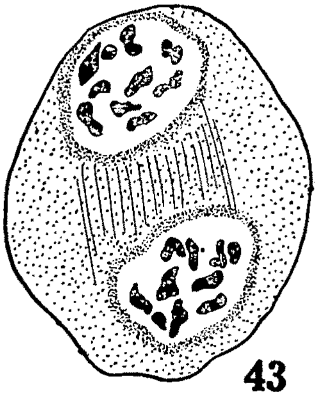

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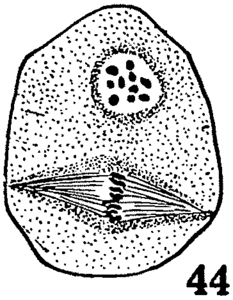

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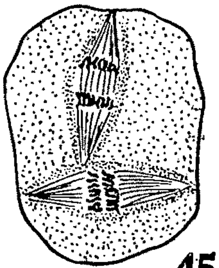

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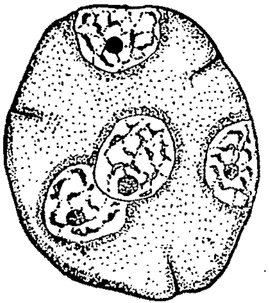

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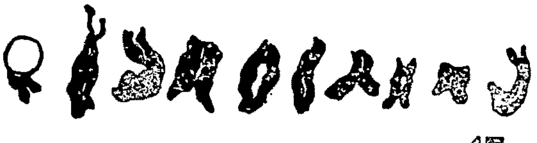

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CONDENSATION OF ALDEHYDES WITH AMIDES, PART XVIII OF 2-CHLORO-, 2:6-DICHLORO- AND 2:4:6-TRICHLORO-3-HYDROXY- AND 3-CHLORO-AND 3:5-DICHLORO-HYDROXY-BENZALDEHYDES

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In Part XVII (6, 7) of this series the condensation of chlorinated derivatives of salicylaldehyde with amides have been described. In the present paper condensations of the three chlorinated derivatives of *m*-hydroxy-benzaldehyde (2- chloro-, 2: 6-dichloro- and 2:4:6-trichloro-) and two chlorinated derivatives of *p*-hydroxy-benzaldehyde (3-chloro-and 3:5-dichloro) with formamide, acetamide, propionamide, *n*-butyramide, *n*-heptamide, urea, benzamide, cinnamamide, phenylacetamide and benzene-sulphonamide are described. The reactions stand in line with those already described in the other chlorinated salicylaldehyde derivatives (6, 7). However in the present work phenylacetamide and benzenesulphonamide failed to condense with 2:6-dichloro- and 2:4: 6-trichloro-3-hydroxybenzaldehydes; benzenesulphonamide failed to condense with 3-chloro- and 3:5-dichloro-*p*-hydroxybenzaldehydes and resinous products were given in reactions of formamide, acetamide and *n*-heptamide with 3-chloro-4-hydroxy-benzaldehyde.

The products, were generally bisamides (B) in contrast to those obtained from the *o*-, *m*- *and p*-hydroxy benzaldehydes (8, 9, 10) which have given only mono-amides (A,C); in this they resembled the chlorinated salicylaldehydes (6, 7). The mono-products were also obtained here in a few cases, e.g. with 2-chloro-3-hydroxy-benzaldehyde and benzene sulphonamide, 2:6-dichloro-3-hydroxy- and 3:5-dichloro-4-hydroxy-benzaldehydes with formamide, and both mono-and bis-amides with formamide and 2:4:6-trichloro-3-hydroxy-benzaldehyde under two different conditions of temperature.

Urea as usual gave two products (a diurea C and a biuret D as below), with 2:6-dichloro-3-hydroxybenzaldehyde and 3:5-dichloro-4-hydroxybenzaldehyde, the diurea being got at the temperature of water bath (98°) and the biuret at temperatures above 132°. The 2-chloro- and 2: 4: 6-trichloro-3-hydroxy-benzaldehydes gave only a diurea both at 98° and at higher

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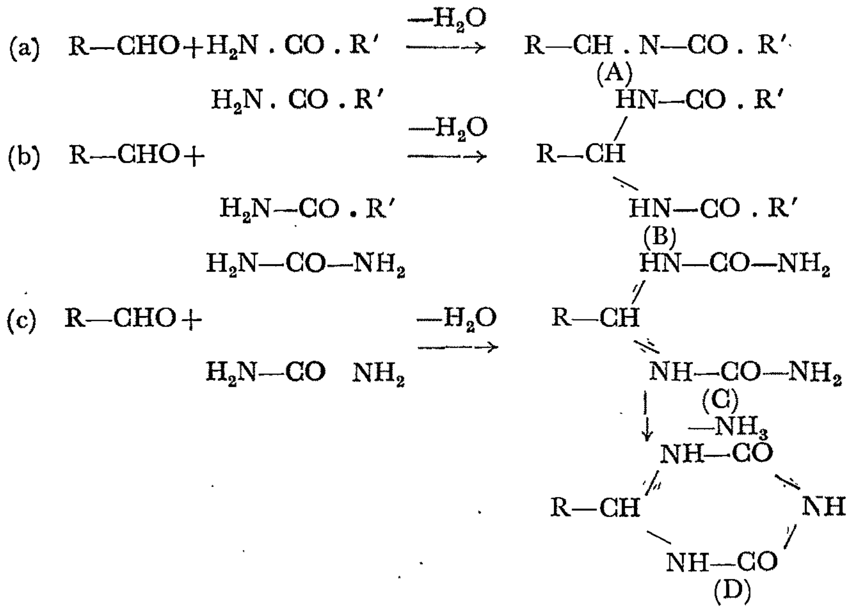
temperatures (150-60°), and 3-chloro-4-hydroxy-benzaldehyde gave only a biuret even at 98°.


(a) R—CHO+H₂N . CO . R′ —H₂O → R—CH . N—CO . R′
(A)
(b) R—CHO+ H₂N . CO . R′ / H₂N—CO . R′ —H₂O → R—CH(HN—CO . R′)(HN—CO . R′)
(B)
(c) R—CHO+ H₂N—CO—NH₂ / H₂N—CO NH₂ —H₂O → R—CH(HN—CO—NH₂)(NH—CO—NH₂)
(C)
—NH₃
R—CH(NH—CO)(NH—CO)NH
(D)

In general the yields were very good and in some cases even quantitative. The use of (0.15 mol) pyridine as a condensing agent was not found helpful. Acetamide failed to condense with 2:6-dichloro-3-hydroxy-benzaldehyde in the presence of pyridine. In urea condensations however, pyridine proved to be very useful and the yields were also quantititive.

Increased temperatures (i.e. above 98°) had generally a good effect on the yields, except in the condensations of 2-chloro-3-hydroxy-benzaldehyde with acetamide, and propionamide, of 2 : 6-dichloro-3-hydroxy-benzaldehyde with cinnamamide, of 2 : 4: 6-trichloro-3-hydroxy-benzaldehyde with acetamide, and of 3-chloro- and 3: 5-dichloro-4-hydroxy-benzaldehydes with all the amides. In the condensations of benzamide, cinnamamide and phenylacetamide with 3:5-dichloro-4-hydroxy-benzaldehyde the reaction did not start at any temperature lower than 155°; 155-65° was found to be the most suitable. A quantitative yield of a mono-amide product with formamide and 2:4:6-trichloro-3-hydroxy-benzaldehyde was obtained at the room temperature (30°).

Use of ethyl alcohol as a solvent in urea condensations was always helpful in improving the yields.

EXPERIMENTAL

Preparation of the Aldehydes.

2-Chloro-, 2:6-dichloro and 2:4:6-trichloro-3-hydroxy-and 3:5-dichloro-4-hydroxy-benzaldehydes were prepared by the methods already described in literature (3, 4, 5, 2). 3-Chloro-4-hydroxy-benzaldehyde was prepared by Biltz's method (2) with slight modifications. A current of dry chlorine was passed into a 20% solution of *p*-hydroxy-benzaldehyde in glacial acetic acid (w/w) kept in ice till the desired increase in weight was attained. The yield obtained was 51.3% of theory.

CONDENSATION OF ALDEHYDES WITH AMIDES.

The general procedure in the condensations had been to heat molecular proportions of aldehydes and amides, with or without condensing agent, under the conditions given in the tables (I, II, III, IV, V). The products were extracted with a mixture of (9.5 c.c. ether and 0.5 c.c. alcohol). This mixture removed all the resinous matter and any unreacted aldehyde. After extraction with the mixture of solvents the residue was washed with water to remove the unreacted amide. The substances were purified by crystallisations either from glacial acetic acid or alcohol. The urea products of 2-chloro-, 2:6-dichloro- and 2:6:6-trichloro-3-hydroxy-benzaldehydes being insoluble in almost all the common organic solvents, were purified by boiling with hot alcohol which gave products with sharp melting-points suitable for analysis. The mono-amide product of 2:4:6-trichloro-3-hydroxy-benzaldehyde and formamide was purified by washing with ether. The products were generally white substances, excepting 2-chloro-3-hydroxy-benzylidene-bisformamide, 2:6-dichloro-3-hydroxy-benzylidene-formamide and 2:4:6-trichloro-3-hydroxybenzylidene-formamide and the biuret compounds which were yellow in colour.

All the products were analysed and identified. The results are shown in Tables (I, II, III, IV, V).

SUMMARY

2-Chloro-, 2:6-dichloro and 2:4:6-trichloro-3-hydroxy and 3-choro- and 3 : 5-dichlhro-4-hydroxy-benzalehydes have been condensed with different amides under different conditions. The products obtained were mostly bis-amides, but in fous cases mono-amide products were obtained. 2:4:6-Trichloro-3hydroxybenzaldehyde gave bout bis and mono-amides with formamide. Urea gave besides a diurea and a biuret compound at the temperature of water bath (98°) and above 132° gave only a diurea with 2-chloro and 2:4:6-trichloro-3-hydroxy-benzaldehydes and a biuret compound with 3-chlor-4-hydroxy-benzaldehyde. Except in urea condensations pyridine as a condensing agent was not helpful.

Attention is invited to several products in each Table having been obtained in 90%to 100% yields. This will interest chemists concerned with organic synthesis.

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TABLE I.

2-Chloro-3-hydroxy-benzaldehyde.

The time of the condensations was about ten hours eaeh here.

Amide.	Mol. Prop. Ald.: Amid.	Condensing Agent.	Temp.	Formula.	%Chlorine Found	%Chlorine Calc.	Melting-point	Yield %	Product
Formamide	1:4	nil	98°	$\mathrm{C_9H_9O_3N_2Cl}$	15.81	15.53	201.5°	12	R-bis-formamide
,,	1:4	Pyrid.	98°	,,			,,	26.7	,,
Acetamide	1:3	nil	98°	$\mathrm{C_{11}H_{13}O_3N_2Cl}$	13.32	13.84	230°	61	R-bis-acetamide
,,	1:3	nil	98°	,,			,,	22.1	,,
,,	1:3	nil	130-40°	,,			,,	15.3	,,
Propionamide	1:3	nil	98°	$\mathrm{C_{13}H_{17}O_3N_2Cl}$	12.11	12.47	208°	82.5	R-bis-propionamide
,,	1:3	Pyrid.	98°	,,			,,	20.7	,,
,,	1:3	nil	110-20°	,,			,,	6.9	,,
n-Butyramide	1:3	nil	98°	$\mathrm{C_{15}H_{21}O_3N_2Cl}$	11.73	11.36	195.5°	75.1	R-bis-*n*-butyramide.
,,	1:3	Pyrid.	98°	,,			,,	12.5	,,
n-Heptamide	1:3	nil	98°	$\mathrm{C_{21}H_{33}O_3N_2Cl}$	8.52	8.95	201°	69.1	R-bis-*n*-heptamide.
,,	1:3	nil	110-20°	,,			,,	88.8	,,
Benzamide	1:3	nil	130-40°	$\mathrm{C_{21}H_{17}O_3N_2Cl}$	8.97	9.33	238°	61.6	R-bis-benzamide.
,,	1:3	Pyrid.	130-40°	,,			,,	30.8	,,
,,	1:3	nil	110-20°	,,			,,	100	,,
Cinnamamide	1:2	nil	98°	$\mathrm{C_{28}H_{21}O_3N_2Cl}$	8.48	8.20	130°	90.4	R-bis-cinnamamide.
,,	1:2	nil	100-10°	,,			,,	99.9	,,
Phenylacetamide	1:2	nil	98°	$\mathrm{C_{23}H_{21}O_3N_2Cl}$	8.21	8.69		23.9	R-bis-phenylacetamide.
,,	1:2	nil	100-10°	,,			210°	95.8	,,
Benzene-sulphonamide	1:2	nil	140-50°	$\mathrm{C_{13}H_{10}O_3NClS}$	11.75	12.01*	,, 188-89°	13 2	R-benzene-sulphonamide
,,	1:2	nil	150-60°	,,			,,	13.2	,,
,,	1:2	nil	140-50°	,,			,,	26.5	,,
,,	1:1	nil	140-50°	,,			,,	92.7	,,
Urea	1:2	Pyrid.	98°	$\mathrm{C_9H_{11}O_3N_4Cl}$	13.90	13.68	208°	98.4	R-diurea.
,,	1:2	nil	98°	,,			,,	98.4	,,
,,	1:2	nil	132-40°	,,			,,	37.4	,,
,,	1:2	Pyrid.	132-40°	,,			,,	45.4	,,

Where R is 2-Chloro-3-hydroxy-benzylidene. (in the last column).

*Sulphur, Found 11-15 %, mono requires 10.82 %

TABLE—II.

2:6—Dichloro-3-hydroxy-benzaldehyde.

Amides.	Mol. Prop. Ald. : Amide.	Conden-sing. Agent.	Time Hours.	Temp.	Formula.	% Chlorine		Melting-point.	Yield %	Product.
						Found	Cal			
Formamide	1:4	nil	49	98°	$C_8H_5O_2NCl_2$	32.15	3250.	213°	26.3	R-monoformamide.
Acetamide	1:3	nil	10	100-10°				240°	26.3	R-bisacetamide.
,,	1:3	nil	10	110-20°	$C_{11}H_{12}O_3N_2Cl_2$	23.97	24.39	240°	26.3	,,
,,	1:3	Pyrid.	10	110-20°	No product.					
Propionamide	1:3	nil	10	98°	$C_{13}H_{16}O_3N_2Cl_2$	22.04	22.25	212°	29.9	R-bispropionamide
,,	1:3	nil	10	100-10°	,,			212°	71.9	,,
n-Heptamide	1:4	nil	10	98°	$C_{21}H_{32}O_3N_2Cl_2$	16.11	16.47	172°	70.9	R-bis-*n*-heptamide.
,,	1:4	nil	10	100-10°	,,			172°	70.9	,,
Benzamide	1:3	nil	10	98°	$C_{21}H_{16}O_3N_2Cl_2$	16.92	17.20	231.5°	73.6	R-bis-benzamide.
,,	1:4	nil	10	100-10°	,,			231.5°	100	,,
Cinnamamide	1:2	nil	10	98°	$C_{25}H_{20}O_3N_2Cl_2$	14.84	15.20	230.5°	77.7	R-bis-cinnamamide.
,,	1:2	nil	10	100-10°	,,			230.5°	32.7	,,
Urea	1:2	nil	10	98°	$C_9H_{10}O_3N_4Cl_2$	24.00	24.23	209°	91.2	R-diurea.
,,	1:2	Pyrid.	10	98°	,,			209°	78.2	,,
Urea	1:2	nil	10	140-50°	$C_9H_7N_3N_3Cl_2$	25.37	25.72	240°	10.4	R-biuret.
,,	1:2	Pyrid.	10	140-50°	,,			240°	20.8	,,
,,	1:2	nil	10	132-40°	,,			240°	41.5°	,,
,,	1:2	Pyrid.	10	132-40°	,,			240°	83.1	,,
Phenylacetamide					Did not condense.					
Benzenesulphonamide					Did not condense.					

Where R is 2:6-Dichloro-3-hydroxy-benzylidene- (in the last column).

TABLE—III

2: 4: 6—Trichloro-3-hydroxy-benzaldehyde

Amides.	Mol. Prop. Ald.: Amide.	Condensing Agent	Time hours.	Temp.	Formula	% Chlorine Found	% Chlorine Calc.	Melting-point.	Yield %	Product.
Formamide	1:2	nil	25	98°	$C_9H_7O_3N_2Cl_3$	35.92	35.79	199°	19	R-bis-formamide.
,,	1:4	nil	53	98°	,,			199°	6.3	,,
,,	1:8	nil	25	98°	,,			199°	50.5	,,
,,	1:17	nil		roomtemp. 30-32°	$C_8H_4O_2NCl_3$	42.43	42.17	228°	100	R-mono-formamide.
Acetamide.	1:4	nil	10	98°	$C_{11}H_{11}O_3N_2Cl_3$	32.99	32.71	225°	57.7	R-bis-acetamide.
,,	1:4	nil	10	110-10°	,,			225°	34.6	,,
Propionamide.	1:3	nil	10	98°	$C_{13}H_{15}O_3N_2Cl_3$	29.63	30.12	208°	95.7	R-bis-propionamide.
,,	1:3	nil	10	100-10°	,,			208°	63.8	,,
n-Heptamide.	1:3	nil	10	98°	$C_{21}H_{31}O_3N_2Cl_3$	23.21	22.88	152°	56.5	R-bis-*n*-heptamide.
,,	1:3	nil	10	110-20°	,,			152°	40.4	,,
Benzamide.	1:3	nil	10	98°	$C_{21}H_{15}O_3N_2Cl_3$	24.01	23.69	204.5°	75.3	R-bis-benzamide.
,,	1:3	nil	10	100-10°	,,			204.5°	50.2	,,
Cinnamamide.	1:2	nil	10	98°	$C_{25}H_{19}O_3N_2Cl_3$	21.01	21.23	235°	45	R-bis-cinnamamide.
,,	1:2	nil	10	100-10°	,,			235°	60	,,
Urea.	1:2	nil	4.5	98°	$C_9H_9O_3N_4Cl_3$	32.21	32.52	138°	68.9	R-diurea.
,,	1:2	Pyrid.	4.5	98°	,,			138°	63.1	,,
,,	1:2	nil	1	150-60°	,,			138°	23	,,
,,	1:2	Pyrid.	1	150-60°	,,			138°	35	,,
Phenylacetamide.					Resins.					
Benzenesulphonamide					Resins.					

Where R is 2: 4: 6—Trichloro-3-hydroxy-benzylidene (in the last column).

TABLE—IV.

3—Chloro-4hydroxy-benzaldehyde.

Amides.	Mol. Prop. Ald.: Amide.	Condensing Agent	Time hours.	Temp.	Formula.	% Chlorine		Melting-point.	Yield %	Product.
						Found	Calc.			
Formamide.					RESINS.					
Acetamide.					RESINS.					
Propoinamide	1:3	nil	10	98°	$C_{13}H_{17}O_3N_2Cl$	12.91	12.47	195.5°	27.5	R-bis-propionamide
"	1:3	nil	10	100-10°	"			195.5°	10.2	"
n-Heptamide					RESINS.					
Benzamide.	1:3	nil	10	98°	$C_{21}H_{17}O_3N_2Cl$	9.01	9.33	216.5°	46.3	R-bis-benzamide.
"	1:3	nil	10	100-10°	"			216.5°	46.3	"
Cinnamamide	1:2	nil	10	110-20°	$C_{25}H_{21}O_3N_2Cl$	8.46	8.20	222°	9.1	R-bis-cinnamamide.
"	1:2	nil	10	120-30°	"			222°	36.2	"
Phenylacetamide.					RESINS.					
Benzenesulphonamide		Did not	con	dense.						
Urea	1:2	Pyrid.	7	132-40°	$C_9H_8O_3N_3Cl$	15.12	14.09	180°	100	R-biuret.
"	1:2	nil	7	132-40°	"			180°	97.2	"
"	1:2	nil	7	98°	"			180°	100	"
"	1:2	Pyrid.	7	98°	"			180°	97.2	"
"	1:2	Pyrid.	7	100-10°	"			180°	97.2	"
"	1:2	nil	7	100-10°	"			180°	100	"

Where R is 3-Chloro-4-hydroxy-benzylidene— (in the last column).

TABLE—V

3:5—Dichloro-4-hydroxy-benzaldehyde.

Amides	Mol. Prop. Ald. : Amide	Conden-sing. Agent.	Time hours.	Temp.	Formula.	% Chlorine.		Melting. point.	Yield %	Product.
						Found	Calc.			
Formamide.	1:2	nil	19	98°	$C_3H_6O_2N_2Cl_2$	32.11	32.42	169°	34.9	R-mono-formamide.
,,	1:2	nil	19	100-10°	,,			169°	17.5	,,
Acetamide.	1:4	nil	15	98°	$C_{11}H_{12}O_3N_2Cl_2$	23.91	24.39	226°	78.8	R-bis-acetamide.
,,	1:4	nil	15	100-10°	,,			226°	65.6	,,
Propionamide.	1:3	nil	12	98°	$C_{13}H_{16}O_3N_2Cl_2$	21.83	22.25	207°	100	R-bis-propionamide.
,,	1:3	nil	12	100-10°	,,			207°	71.9	,,
n-Heptamide.	1:4	nil	12	98°	$C_{21}H_{32}O_3N_2Cl_2$	16.12	16.47	202.5°	88.6	R-bis-*n*-heptamide.
,,	1:4	nil	12	100-10°	,,			202.5°	79.8	,,
Benzamide.	1:3	nil	10	155-65°	$C_{21}H_{16}O_3N_2Cl_2$	17.48	17.10	250°	100	R-bis-benzamide.
,,	1:3	nil	15	155-65°	,,			250°	100	,,
Cinnamamide.	1:2	nil	10	155-65°	$C_{25}H_{20}O_3N_2Cl_2$	15.01	15 20	244°	65.4	R-bis-cinnamamide.
,,	1:2	nil	15	155-65°	,,			244°	98.2	,,
Phenylacetamide	1:2	nil	10	155-65°	$C_{23}H_{20}O_3N_2Cl_2$	16.37	16.02	216°	8.6	R-bis-phenylacetamide
,,	1:2	nil	15	155-65°	,,			216°	8.6	,,
,,	1:2	nil	10	180-90°	,,			216°	38	,,
Benzenesulphonamide	1:2			Did not	condense.					
Urea.	1:2	Pyrid	10	98°	$C_9H_{10}O_3N_4Cl_2$	24.72	24.23	190°	97.7	R-diurea.
,,	1:2	nil	10	98°	,,			190°	78.2	,,
Urea	1:2	Pyrid	10	132-40°	$C_9H_7O_3N_3Cl_2$	25.94	25.72	201°	55.4	R-biuret.
,,	1:2	nil	10	132-40°	,,			201°	41.5	,,

Where R is 3:5—Dichloro-hydroxy-benzylidene—(in the last column).

THE GENITALIA AND REPRODUCTIVE ORGANS OF BRINJAL FLEA BEETLE, PSYLLIODES BRETTINGHAMI BALY (CHRYSOMELIDAE: COLEOPTERA)

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Introduction

The genitalia of the different families of Coleoptera have formed the subject of comprehensive study by a large number of workers, including, among others, Verhoeff (1893, 1894 and 1918), Heymons (1899), Wandolleck (1905), Sharp and Muir (1912), Sharp (1918), Tanner (1927), Wilson (1926, 1929 and 1930), Pradhan (1935), Khatib (1946), Ibrahim (1948), and Mukerji and Chatterjee (1951). The work done by these authors, however, either covered too wide a field or was too specialised in its scope to include a detailed study of the genitalia of the flea beetles belonging to the subfamily Alticinae of the family Chrysomelidae. More recently, Varma (1955) has made a phylogenetic study of the family Chrysomelidae based on genitalia, but this work deals only with the salient characters of genitalia in the different subfamilies of Chrysomelidae and not detailed descriptions of the genital armature.

The position in respect to the structure of the reproductive organs of the flea beetles is much the same. Although a number of workers like Pruthi (1924), Metcalfe (1932), Wilson (1934), Williams (1945), Khatib (1946), and Srivastava (1953), have done valuable work on the structure of the reproductive organs of certain species of beetles, no satisfactory descriptions of the reproductive organs of the flea beetles have been published. The present work has, therefore, been undertaken to study the structure of the genitalia and reproductive organs of one of the members of this important group of beetles. The brinjal flea beetle, *Psylliodes brettinghami* Baly, was selected for study material because of its great economic importance and plentiful availability.

The terminology as recently suggested by Mukerji and Chatterjee (1951) in partial modification of the system followed by Snodgrass (1935) for Coleoptera in general has been adopted in this paper for the description of the male genital armature. For the description of the female genitalia, however, the system followed by Tanner (1927) has been adopted.

Material and Methods

The insects used in the course of the present work were obtained by direct catches from the infested brinjal plants.

Insects required for the study of genitalia were killed in hot distilled water or 70% alcohol. They were next put in 10% KOH solution and heated upto boiling point. The specimens were then washed for some time in water, transferred to a slide and dissected in a drop of water under a binocular microscope. The dissected parts were then gradually dehydrated upto 90% alcohol, after which they were stained with acid fuchsin. Differentiation was achieved by treating the parts with acidulated 90% alcohol, after which they were dehydrated and cleared in clove oil. The cleared parts were put in a drop of Canada balsam on the slide, when they could be further dissected out to remove all extra chitin and adjusted in a dorsal, ventral or lateral position as suitable and mounted.

For studying the reproductive organs, the beetles were anaesthesised with chloroform. They were then dissected with very fine micro-needles in 0.75% normal saline solution under the binocular microscope. Permanent preparations of the reproductive organs were made after staining with alcoholic borax carmine.

All drawings were made with the aid of a camera lucida.

THE GENITALIA

The abdomen, in both the male and the female beetles, shows only seven visible segments, each bearing a pair of spiracles (*Sp.*). The eighth, ninth and tenth segments normally remain retracted within the seventh with which they remain connected by membrane. The seventh abdominal tergum (*T7*) is similar in both sexes and is well developed and convex dorsally. It is shield-like, setiferous, broad at its base and narrowed posteriorly. The seventh sternum (*S7*), however, differs in the two sexes; in the female the posterior edge of the seventh sternum is broadly rounded (Fig. 1), while in the male it is extended in the middle as a small, semi-circular sclerite covered with fine hairs (Fig. 5). This morphological difference is used for differentiating the two sexes.

Genitalia of the Female (Figs. 1—4).—The female genitalia, which consist of the eighth, ninth and tenth abdominal segments, are of the elongate type. The eighth segment is much modified and, as in other beetles, lacks genital appendages. Contrary to the observation made by Tanner (1927) in the species of beetles studied by him, no spiracle is borne on this segment in *P. brettinghami*. The tergite of this segment (*T*8) is sclerotized and setiferous and is divided in the middle into two parts by a small strip of membrane. The sternite is largely membranous except for two small sclerites (*S*8) in its wall and bears a long apodeme (*Ap.*) which extends cephalad into the body. It is provided with numerous spines on the meso-posterior margin. The ninth segment is entirely membranous and carries in the mid-ventral region a pair of large, close-set, unjointed coxites (*Cx*) bearing long spines at their terminal ends. The vulva (*Vul.*) is located in the corea between the coxites. The

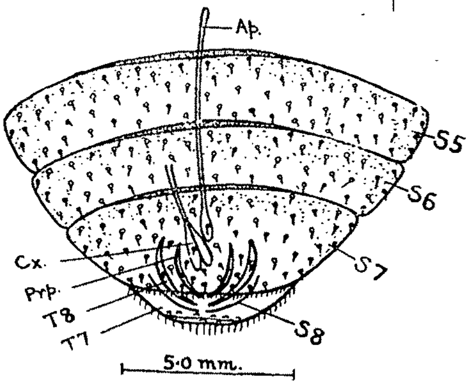


Fig. 1

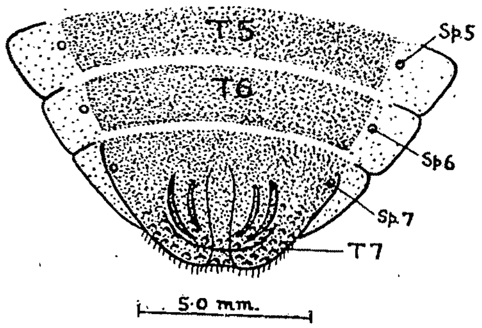


Fig. 2

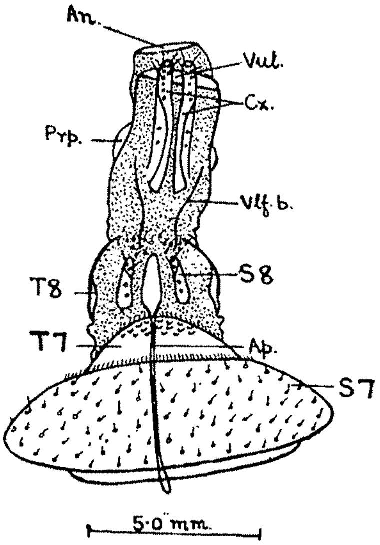


Fig. 3

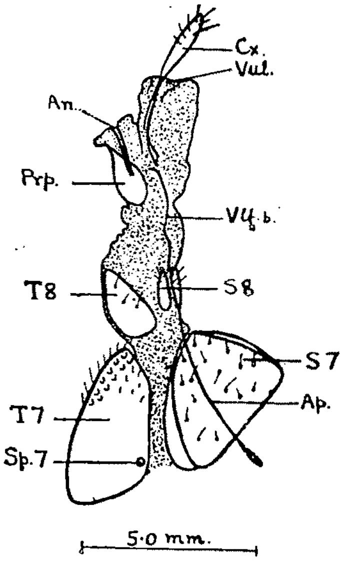


Fig. 4

Figs. 1—4: Female Genitalia of *Psylliodes brettinghami* Baly. Fig. 1. Posterior part of female abdomen, ventral view. Fig. 2. Posterior part of female abdomen,dorsal view. Fig 3. Genitalia of the female, ventral view. Fig. 4. Genitalia of the female, lateral view.

styli are absent. The valvifers are reduced to two long thin sclerotised rods or baculi (*Vlf.b.*) which articulate loosely with the coxites. The paraprocts (*Prp.*), which according to Tanner (1927) may be a part of the ninth tergum, are well developed as more or less triangular sclerites, separated by a narrow strip of membrane along the mid-dorsal line, and slightly extending over the pleural regions of the ventral side. Their lateral borders are well sclerotised and provided with a few spines. Below the paraprocts is situated the anus (*An.*), surrounded by a membrane which probably represents the proctiger; a distinct sclerotised proctiger is absent.

Genitalia of the Male (Figs. 5—8).—

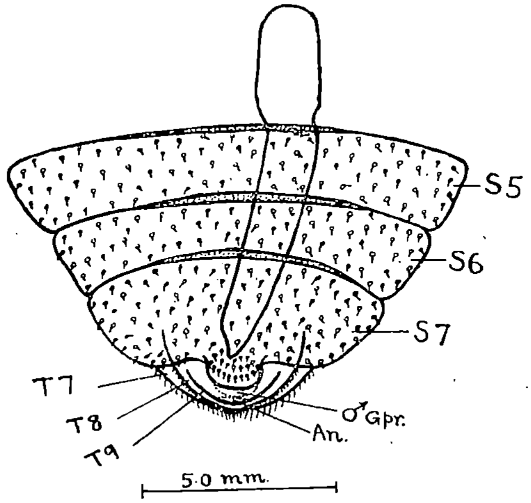


Fig. 5

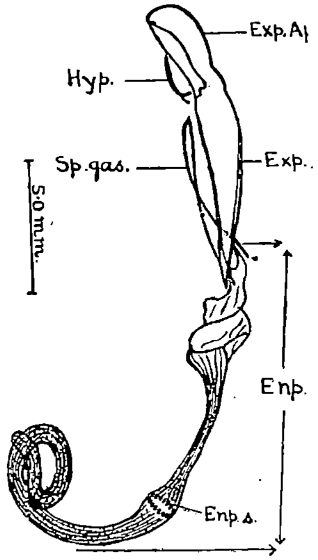


Fig. 6

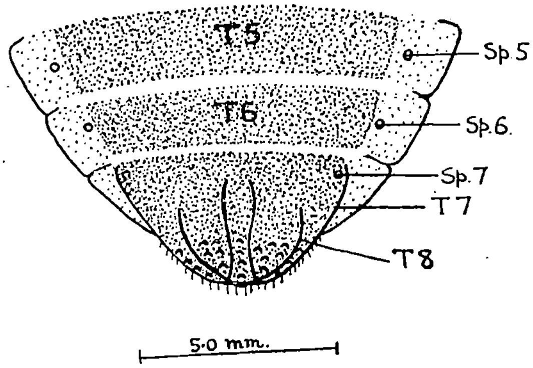


Fig. 7

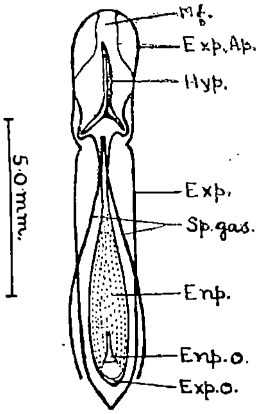


Fig. 8

Figs. 5-8. Male Genitalia of *Psylliodes brettinghami* Baly. : Fig. 5. Posterior part of male abdomen, ventral view. Fig. 6. Genitalia of the male with the endophallus completely everted, lateral view. Fig. 7. Posterior part of male abdomen, dorsal view. Fig. 8. Genitalia of the male, ventral view.

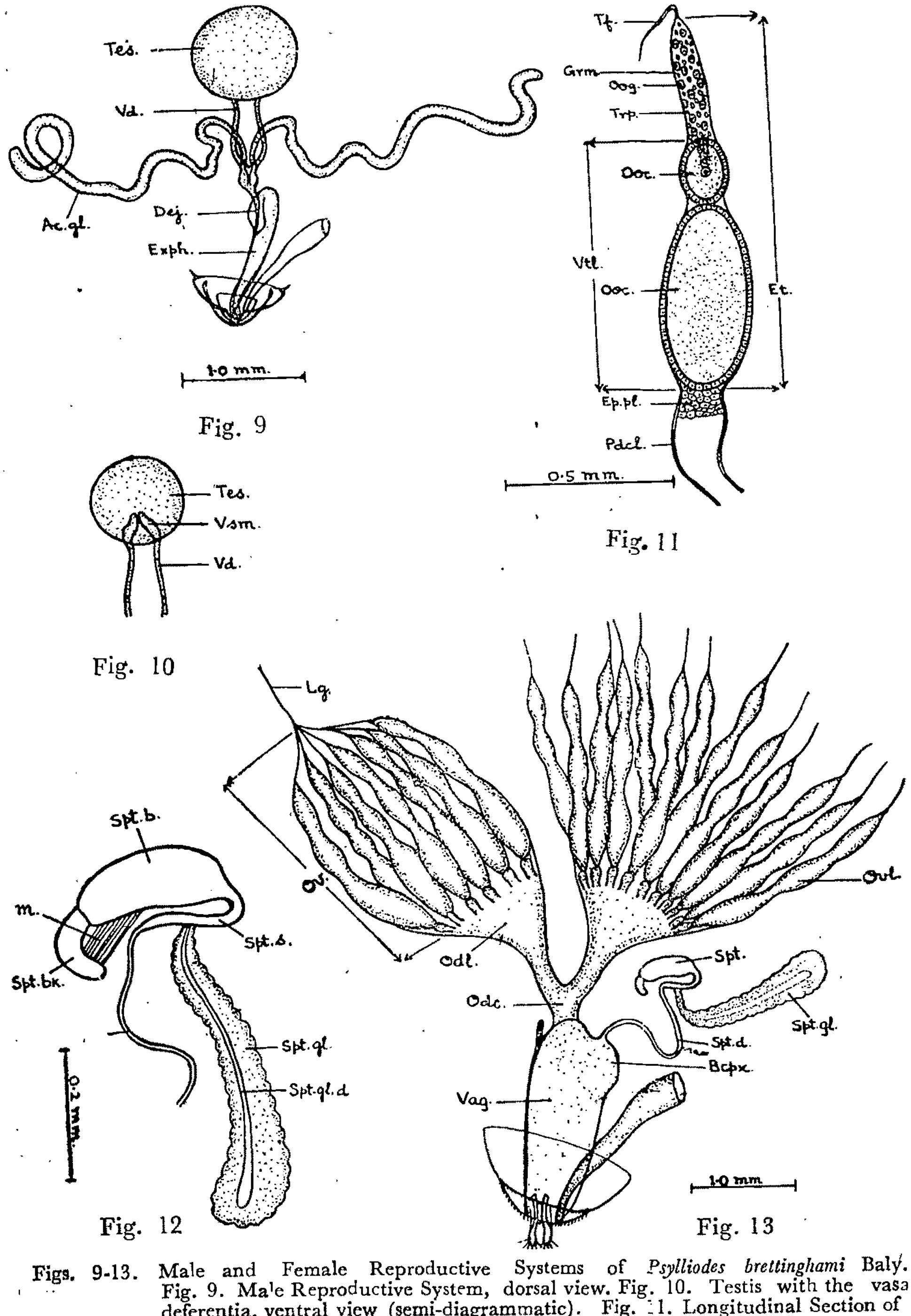
In the male the eighth tergum (*T*8) is present as a complete well sclerotised and setiferous sclerite, but it remains completely concealed below the seventh. The ninth tergum (*T*9) is represented by a small sclerite; while the tenth tergum is absent; the anus is located underneath the ninth tergum. The posterior edge of the seventh sternum is produced backwards in the middle as a small, semi-circular sclerite and along this area the phallic organ slides during copulation. The eighth sternum is not seen. The ninth sternum is completely membranous, and in repose is invaginated into the body cavity forming the genital chamber in which the phallic organ lies.

The structure of the male genitalia is essentially coleopteroid, there being no periphallic armature, such as, gonopods, harpagones and styli. The phallic organ consists of a phallobase (tegmen of Sharp and Muir) and an exophallus (median lobe of Sharp and Muir; aedeagus of Snodgrass; *Exp.*). The phallobase is without any basal piece, and is represented only by a ventrally situated, lightly sclerotised, inverted Y-shaped rod, the hypomere (tegminal strut of sharp and Muir; *Hyp.*). The arms of the Y are loosely articulated with the two lateral grooves in the wall of the exophallus, while the stem runs along its ventral side pointing anteriorly. There are no parameres (lateral lobes of Sharp and Muir) or epimere (dorsal lobe).

The exophallus is a well sclerotised, long and straight, tubular structure extending between the fourth to the seventh sterna. The exophallic orifice (median orifice of Sharp and Muir; *Exp. o.*) is situated on the dorsal wall of the exophallus near its posterior end. The ventral edge of the exophallic orifice is produced into a point, projecting beyond the dorsal edge. The pointed apex of the exophallus apparently serves for opening the external genital aperture of the female during copulation. The basal part of the exophallus is produced into an exophallic apodeme (median strut of Sharp and Muir; *Exp. Ap.*), which is arched and well rounded off proximally.

The ejaculatory duct (*Dej.*) enters the exophallus near its base on the ventral side through a wide opening (median foramen of Sharp and Muir; *Mf.*) and inside its tubular cavity expands into the eversible endophallus (internal sac of Sharp and Muir; *Enp.*). When in repose the endophallus lies introverted within the exophallus, with the endophallic orifice (pseudogonopore; *Enp.o.*) occupying a position just inward of the exophallic orifice. During copulation, however, eversion of the endophallus takes place through the exo—and endophallic orifices, and the opening of the ejaculatory duct is then brought to its tip which thus functions as the true gonopore. In its everted condition, the endophallus is clearly demarcated into two regions—an anterior saccular distended region and a posterior non-saccular tubular region. The surface of the posterior tubular region is beset throughout its length with minute spines which appear to be arranged in longitudinal rows. Besides these, there are also larger spines (*Enp. s.*) arranged in a circle near the proximal third of the tubular region, where it appears slightly widened. The endophallic armature of spines, which becomes external with eversion of the endophallus, apparently serves for efficient clasping of the intromittent organ in the copulatory pouch of the female.

THE REPRODUCTIVE ORGANS (Figs. 9-13)



Figs. 9-13. Male and Female Reproductive Systems of *Psylliodes brettinghami* Baly. Fig. 9. Male Reproductive System, dorsal view. Fig. 10. Testis with the vasa deferentia, ventral view (semi-diagrammatic). Fig. 11. Longitudinal Section of an ovariole. Fig. 12. Spermatheca with its duct and gland. Fig. 13. Female Reproductive System, dorsal view.

Associated with the male genitalia is a ventrally situated, well sclerotised, inverted V-shaped bar (spiculum gastrale of Verhoeff; spicule of Sharp and Muir; *Sp. gas.*). The arms of the V are slender rods, which after running closely together for a short distance, diverge abruptly and then converge again a little so as to embrace the genital chamber posteriorly. This bar is considered by some authors (Sharp and Muir, 1912) to represent the ninth sternum. It is not a part of the exophallus but serves for the attachment of muscles which are employed in protracting and retracting the genital chamber and the exophallus.

Female Reproductive Organs.—

The female reproductive organs are situated ventrally below the alimentary canal. They consist of the two ovaries (*Ov.*), the two lateral oviducts (*Odl.*), the median oviduct (*Odc.*), the vagina (*Vag.*), the bursa copulatrix (*Bcpx.*), and the spermatheca (*Spt.*) with its gland (*Spt. gl.*) and duct (*Spt.d*).

The ovaries are situated between the second and the fourth abdominal segments. Each ovary consists of a group of 13 cylindrical tubes or ovarioles (*Ovl.*) The ovarioles converge upon the anterior end of the corresponding lateral oviduct. The anterior part of each ovariole is the terminal filament (*Tf.*). The terminal filaments of all the ovarioles in each ovary are united distally to form the suspensory ligament (*Lg.*), which is attached to the fat body in the region of the metathorax.

Each ovariole consists of three parts; the terminal filament (*Tf.*), the egg tube (*Et*), and the pedicel (*Pdcl.*). The terminal filament, which is a part of the suspensorial apparatus of the ovary, is a fine, thread-like filament arising from the anterior end of the ovariole. The egg tube, which forms the second division of the ovariole, is the largest and the principal part of the ovariole. It consists of the germarium (*Grm.*) and the vitellarium (*Vtl.*). The germarium is the anterior region of the ovariole, below the terminal filament. It is more or less cylindrical in form and granular in nature. It contains the germ cells or oogonia (*Oog.*), and the smaller nutritive cells or trophocytes (*Trp.*). The germarium is followed by the vitellarium, which is larger in size and is divided into a series of egg-chambers or follicles that contain the developing oocytes (*Ooc.*). The ovariole is of the acrotrophic type. The pedicel, which forms the lowermost part of the ovariole, is a short duct connecting the egg tube with the lateral oviduct. The upper part of this tube is filled with a mass of follicle cells forming the epithelial plug (*Ep.pl.*) of the egg tube.

Each lateral oviduct is a comparatively long tube, which is narrow in the immature female but becomes greatly expanded in the mature individual. The two lateral oviducts unite to form the common median oviduct. This is a short and wide tube, opening posteriorly by the gonopore into the anterior end of the vagina.

The vagina has the form of a wide tubular passage, which gradually narrows posteriorly and opens to the exterior by the vulva between the two coxites. It receives at its anterior end, both the apertures of the gonopore ventrally and the bursa copulatrix dorsally. The vagina is supported on a long apodeme running ventrally along its length. The average maximum width of the vagina in the region of the bursa copulatrix is 0.4 mm.

The spermatheca is distinguishable into three parts: a proximal narrow tubular stem (*Spt. s.*), followed by the broad bean-shaped main body (*Spt. b.*), arched dorsally and placed nearly parallel to the stem, and a distal hook-shaped beak (*Spt. bk.*) with rounded apex. The tubular stem leads into the spermathecal duct (*Spt. d.*) which is a curved tube running downwards and backwards to open into a conical chamber, the bursa copulatrix. The bursa copulatrix in turn opens in the antero-dorsal part of the vagina. The walls of the spermatheca are thickened and well sclerotised. Between the beak and the main body of the spermatheca extends a transverse band of muscle fibres (m.). The spermatheca measures on the average 0.27 mm. long (from one extremity to the other) and 0.07 mm. broad (widest part).

Below the spermatheca, there is the spermathecal gland (*Spt. gl.*), which is a comparatively long, tubular, nodulated gland, which gradually expands towards its distal blind end. Proximally it opens in the middle of the spermathecal stem and pours its secretion through a narrow duct, the spermathecal gland duct (*Spt. gl. d.*), which runs the entire length of the gland.

Female accessory glands are totally absent.

Male Reproductive organs.—

The male reproductive organs comprise the median testis (*Tes.*), the two vasa deferentia (*Vd.*), the vesicula seminales (*Vsm.*), the ejaculatory duct (*Dej.*) and the accessory gland (*Ac.gl.*).

The large median testis occupies a mesial position in the abdominal region between the second and third segments and is situated dorsal to the alimentary canal. It is a simple, sac-like organ almost spherical in outline. The testis leads on the ventral side into two vasa deferentia, which are small slender tubes swollen at their proximal ends to form the vesicula seminales. The two vasa deferentia open posteriorly into the ejaculatory duct along its lateral sides. The ejaculatory duct also receives a pair of convoluted accessory glands along its mesial surface. It shows a slight dilatation at its proximal end, and then runs posteriorly as a slender tube which pierces the ventral proximal part of the exophallus (aedeagus of Snodgrass).

ACKNOWLEDGEMENT

The author is greatly indebted to Dr. U.S.Sharga, Professor and Head of the Zoology-Entomology Section, Government Agricultural College, Kanpur, for providing necessary laboratory facilities for work and for going through the manuscript and offering valuable suggestions.

SUMMARY

1. The genitalia and reproductive organs of an Indian Alticine beetle are described in greater detail than hitherto attempted.

2. In both the male and the female only seven abdominal tergites and sternites are seen. Morphological differences between the two sexes in regard to the structure of the seventh sternite are given.

3. The female genitalia are described. The eighth segment is much modified and bears a long apodeme extending cephalad into the body. The ninth segment is largely membranous with a pair of large, close-set, unjointed coxites; styli absent; valvifers reduced to two long thin sclerotised rods or baculi; paraprocts well developed as more or less triangular sclerites. A sclerotised proctiger is absent.

4. The male genitalia are essentially coleopteroid, the periphallic armature being entirely absent. Exophallus well-sclerotised, long and straight, tubular structure, with the exophallic orifice situated on its dorsal wall near the posterior end; ventral edge of the exophallic orifice produced into a point projecting beyond the dorsal edge; basal part of exophallus produced into an arched apodeme. Phallobase without a basal piece and represented only by the ventrally situated inverted Y-shaped rod or hypomere. Endophallus large, with an anterior distended region and a posterior tubular region; the latter furnished with numerous minute spines throughout its length and a circle of larger spines near its proximal third. A well-sclerotised, inverted V-shaped bar or spiculum gastrale is present.

5. The female reproductive system, together with the histological structure of an ovariole, has been described. There is a pair of ovaries, each consisting of 13 acrotrophic ovarioles. A characteristic bean-shaped spermatheca with its long, tubular gland is present. Accessory glands are totally absent.

6. The male reproductive system is described. It consists of a large median testis with two separate vasa deferentia leading from its ventral side. A single pair of accessory glands is present.

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*Original not seen.

STUDIES ON POWDERY MILDEW OF *FOENICULUM VULGARE* FROM AJMER

1. Symptoms, Morphology, Spore germination, Phenological relations and efficacy of Sulphur dust against the disease.

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Introduction

Foeniculum vulgare (Fennel) is an important crop of Ajmer. The fruits are used medicinally and as condiments. For the last two years the crop is being severelly affacted by the mildew and the loss due to this disease is considerable. For the first time the writer with the co-operation of Agriculture department, has studied the symptoms, morphology of the Fungus and the efficacy of the fungicides against this disease.

Material and Methods

The localities where the plants were affacted by this disease were visited thrice a week to study the symptoms. The leaves, stems and fruits affacted by the fungus were fixed in 70% Alcohol for the histological study. Sulphur dust was used to see the efficacy against this disease. The phenological data was obtained from the Agriculture department, Ajmer.

Symptoms

In the month of February the mildew was observed on *Foeniculum vulgare* in some fields in the out skirts of Ajmer. A similar type of mildew has been studied on *Cuminum cyminum* L. (Uppal etal 1939, Joshi 1956), *Anethum graveolens* (Joshi 1956) and *Trigonella foenum-graecum* (Joshi 1957). The disease was evident by the formation of small white greyish specks that were found on the lower surface of the leaf and later on, on the stem, flowers and fruits. The leaves in some cases got deformed and crinckled and become smaller in size. The plants were stunted and fruits were smaller and bitter in taste. There was considerable reduction in yield of the crop.

Morphology of the fungus

The microscopic examination of the fungus in diseased fruits, stem and leaves showed that it formed a network containing creeping hyaline, superficial, septate and branched mycelium. The haustoria were found in the epidermal cells. The hyphae had granular contents and its thickness measured on an average 6μ and some of the hyphal threads gave rise to erect short conidiophores. The conidiophores were stout and tall ranging from 115μ to 180μ in length. The conidia were hyaline, unicellular, barrel shaped and produced in chains at the tip of the conidiophores. The conidia were flat ended varying from 36μ to 40μ x 13μ to 18μ in dimension. (Fig. 1). The nature, shape and size of the conidia and mycelium resemble very much with that of *Oidium* Sp. but so far the perfect stage of this fungus has not been seen on this host from any part of the world.

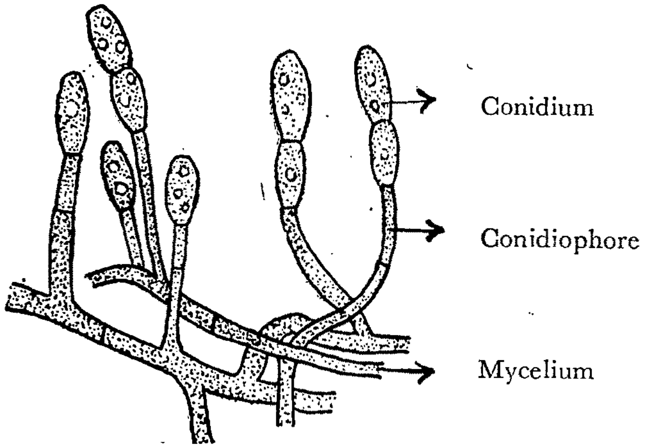

Fig. 1. Diagram showing conidia, conidiophores and mycelium (drawn from cameralucida) magnification 450 times.

SPORE GERMINATION STUDIES

It was observed that fresh conidia germinated immediately (after 5 or 6 hours) but did not retain their germinatibility after 15 days when they were completely dried. The spores were capable of germination only within a narrow range (table No. 1). The germination was optimum at 22-24°C., but below 16° C. and above 32° C. the spores were incapable of germination as shown in table No. 1.

Table I

Showing the % of germination of spores at different temperature

S.No.	Temperature	% of germination.
1.	16° C.	0%
2.	17-21° C.	10-20%
3.	22-24° C.	30-60%
4.	25-27° C.	45-48%
5.	28-31° C.	10-15%
6.	32° C.	0%

PHENOLOGICAL RELATIONS OF MILDEW—

In order to arrive at some definite conclusion as to the relationship of the mildew with daily weather conditions during the growing period of *Foeniculum vulgare* it was observed that the air temperature exerts a great influence on the development of powdery mildew by accelerating the rate of the growth of the fungus and the production of the spores. It will be observed from the table No. 2 that the maximum temperature during majority of the days, in the months of February and March did not fall below 78°F. in 1956 and the disease intensity was maximum during these months as shown in Fig. 2.

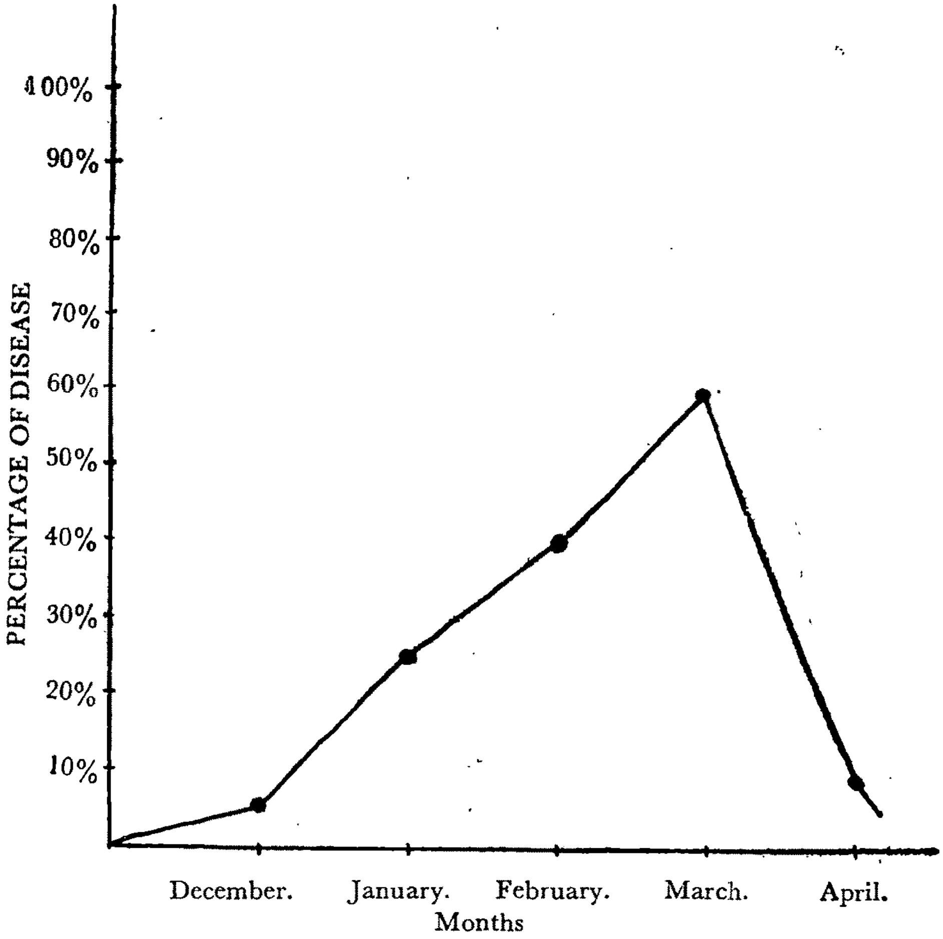

Fig. 2. Graph showing the % of disease in the months of Dec. 1955, Jan. Feb. March. and April, 1956

Table II

Showing the frequency of favourable and unfavourable temperature for mildew during December 1955; Jan. Feb., and March 1956 at Ajmer.

Year	Number of days in each month with favourable and unfavourable temperature indicated.							
	Temperature below 78 F. (Unfavourable)				Temperature between 78-95 F. (Favourable)			
1955 & 1956.	Dec.	Jan.	Feb.	March.	Dec.	Jan.	Feb.	March.
	30	31	4	0	1	0	24	31

Rainfall—Jan. 27 inches; Feb. nil; March .52 inches; (1956) December—1.2 inches (1955).

It is clear therefore that the warmer temperature of February and March caused mildew to become an epidemic resulting to a serious damage to the crop during 1955-56.

EFFICACY OF SULPHURDUST

In order to see whether there is any affect of Sulphur dust against this disease, 3 Fennel growing plots were taken at Loghal village for the experiments and equal number were kept as control. Three applications of Sulphur dusting were done. The first application was conducted when the plants were about to flower, second at the time of full flowering and the last at the time of seed formation. Approximately 25 lbs. of Sulphur per acre was applied. It was observed that except in plot A the powdery mildew was entirely absent in the experimental plots while in the control plots appreciable number of plants were affected by the disease as shown in table No. 3.

TABLE III

Showing the amount of Sulphur used in dusting and the intensity of the disease in Experimental and control pots,

Expt. plots	size of Expt. plots	Quantity of Sulphur required			Total quantity of Sulphur	% of disease in experimental plots.	Control plts	Size of control plots	% of disease in control plots.
		Jan.	Feb.	March.					
A.	1.5 Acre	7.5 lbs.	15 lbs.	15 lbs.	37·5 lbs.	3%	A^1	1·5 Acres	60%
B.	1 Acre	5 lbs.	10 lbs.	10 lbs.	25 lbs.	0%	B^2	1 Acre	58%
C.	1 Acre	5 lbs·	10 lbs.	10 lbs.	25 lbs.	0%	C^3	1 Acre	70%

It will be observed from the table No. 3 that the disease can be controlled by the application of Sulphur dust at the said rate at its early appearance.

SUMMARY

A serious powdery mildew of *Foeniculum vulgare* has been reported from Ajmer.

The symptoms of the disease, morphology of the Fungus, spore germination and the phenological relations of the disease have been described.

Application of the Sulphur at the rate of approximately 25 lbs. per acre is proved to be the best control measure against this disease.

ACKNOWLEDGEMENT

I am grateful to the authorities of the Agriculture Department for supplying the phenological data and other facilities. My thanks are also due to Principal Bhim Sen and Prof. B. Tiagi for inspiration.

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AMMONIUM SALT OF N-B-NAPHTHYL MALONAMIC ACID AS A REAGENT FOR THE QUANTITATIVE ESTIMATION OF METALS

By M. L. Bhambhani and H. D. Mathur, *Chemistry Department, St. John's College, Agra.*

Organic reagents are now extensively used for the detection as well as estimation of metals. This paper deals with the use of ammonium salt of N-B naphthyl malonamic acid (1) as a reagent for the quantitative estimation of copper, zinc, manganese and cobalt

$$H_2C{<}\begin{matrix}COONH_4\\CONH{\cdot}C_{10}H_7\end{matrix}$$

I

N-β-naphthyl malonamic acid was first prepared in the laboratory by Banerjee and Ittyerah (unpublished) by the reaction between ethyl malonate and β-napthylamine and the subsequent hydrolysis of the ethyl ester of N-β-naphthyl malonamic acid obtained. This acid is a white crystalline compound, M.P. 173° C and its ammonium salt, which is soluble in water is prepared in the usual manner by heating the acid with excess of ammonium hydroxide and boiling the excess off.

Qualitative experiments with the ammonium salt showed that well defined crystalline salts of metals can be formed by taking aqueous solution of chloride, sulphate or a nitrate of a metal and adding to it an aqueous solution of the ammonium salt. Thus copper gave a pale green crystalline salt, manganese gave a flesh coloured compound, cobalt gave a pink crystalline derivative, and zinc a white crystalline compound. All of them were soluble in hot water but crystallised on cooling. Further experiments showed that this ammonium salt could be used to precipitate the above metals quantitatively from the aqueous solution of these salts. The general procedure has been to prepare a standard solution (generally N/30 solution was found to give the best results, a higher dilution gave low results while stronger solutions needed larger quantities of the precipitant) of a soluble salt in water. A known volume of the solution was taken in a beaker, warmed and a 5% solution of the precipitant was added, stirring constantly till the precipitation was complete. The beaker was then heated on a steam bath for 5 minutes and cooled to room temperature. The crystalline precipitate was then filtered through a fine sintered glass crucible, washed with cold water, once or twice, and dried in an air oven at 100° to 105° C. From the weight of the precipitate obtained the amount of the metal was calculated. For example, a copper salt was found to have formula (II).

$$\left(H_2C{<}\begin{matrix}CO.NH.C_{10}H_7\\COO\end{matrix}\right)_2Cu.\tfrac{1}{2}H_2O$$

II

Similar compounds were given by manganese, cobalt and zinc. Estimations carried out by the above method gave good results and the percentage error ranged between .01 to .054 (refer table below).

Metal	Salt Taken	Concentration	Volume used	Value obained	Theoritical Value
Copper	$CuSO_4$,·$5H_2O$	N/30	5 cc	·09764 gms.	·09772 gms.
Manganese	$MnCl_2$, $4H_2O$	N/30	5 cc	·00921 gms.	·00916 gms.
Cobalt	$Co(NO3)_2$,$6H_2O$	N/30	5 cc	·00981 gms.	·00983 gms.
Zinc	$Zncl_2$.	N/30	5 cc	·0109 gms.	·01085 gms.

Several other metals like cadmium, lead, calcium, chromium, mercury and thorium are also being tried. Encouraging results have been obtained. But it needs further confirmation. This is being undertaken.

Another interesting fact that has been noted in connection with the present work is that this method can be used in the separation and estimation of zinc and manganese salts. Advantage is taken of the difference in the solubilities of the zinc and manganese salts of N-β-naphthyl malonamic acid in 25% aqueous alcohol. The former is insoluble while the latter is soluble. Thus the two salts can be separated. The manganese salt was then precipitated by evaporating off the alcohol on the steam bath, diluting the residue and cooling.

Further work on the separation of metals of different groups is under progress.

EXPERIMENTAL

Copper. 5 cc. of a standard solution of copper sulphate of approximately N/30 strength was diluted to 15 cc. and heated to 70° C. To this hot solution 5% solution of the ammonium salt of N-β-napthyl malonamic acid was added slowly to complete precipitation, stirring constantly. This was digested on a steam bath for about 5 minutes. It was cooled, the precipitate was filtered through a sintered crucible No. 4, washed with cold water, dried in the air oven at 100 to 105° C and weighed.

Calculated weight of copper .... = .09764 grm.
Found weight of Copper .... = .09772 grm.
Percentage error.. = .102

Cobalt. 5 cc. of a standard solution of Cobalt Nitrate of approximately N/30 strength was taken. It was diluted to 15 cc. with cold water and was completely precipitated with the reagent in cold. The rose-coloured precipitate so obtained was digested on the steam bath for 5 minutes when some of it went into solution. On cooling it was again precipitated. It was then filtered through sintered crucible No. 4, washed with cold water and dried in the air oven at 105-110° C.

Calculated weight of Cobalt	.00983 grm.
Found weight of Cobalt	.00981 grm.
Percentage error	.20

Manganese. 5 cc. of a standard solution of Manganese Chloride of approximately N/30 strength was diluted to 20 cc with cold water. A buff coloured precipitate was obtained when 5 % cold solution of the precipitant was added. It was digested on a steam bath for 5 minutes when some of it went into solution. On cooling it was re-precipitated. It was cooled and filtered through a sintered crucible No. 4, washed with a small quantity of cold water, dried in the air oven at 100-105° C and weighed.

Calculated weight of Manganese .... = .00916 grm.
Found weight of Manganese.............................. = .00921 grm.
Percentage error .... = .54

Zinc. In the case of zinc better results were obtained with lower dilution. Therefore, N/40 solution of Zinc Chloride was used. 5 c.c. of that solution was diluted to 20 cc. with cold water and completely precipitated with the reagent in cold. It was digested on the steam bath for 5 minutes, washed with cold water, dried in the air oven at 105° C and weighed.

Calculated weight of Zinc	.01085 grm.
Found weight of Zinc	.0109 grm.
Percentage error	.046

SEPARATION OF ZINC AND MANGANESE

5 cc. each of the standard solutions of zinc chloride and manganese chloride of the same concentration as mentioned above were mixed together in a beaker. It was diluted to 30 cc. with cold water. Both the metals were completely precipitated with the precipitant in cold. It was heated on the steam bath for 5 minutes, cooled and filtered through the sintered crucible No. 4. The precipitate was washed with 25 % aqueous alcohol when manganese dissolved. It was received in the filtrate. The insoluble precipitate of the zinc salt was dried at 105-110° C and weighed. The filtrate containing the manganese compound was evaporated nearly to dryness cooled and diluted with 2-3 cc. of water when the precipitate was re-obtained. It was digested on the steam bath for 5 minutes, cooled, filtered through the sintered crucible No. 4, washed with cold water, dried in the air oven at 105-110°C and weighed.

Estimation of Zinc

Calculated weight of Zinc	.01085 grm.
Found weight of Zinc	.01084 grm.
Percentage error	.09

Estimation of Manganese

Calculated weight of Manganese	.00916 grm.
Found weight of Manganese	.00915 grm.
Percentage error	.109

SUMMARY

Zinc, Cobalt, Manganese and Copper have been quantitatively estimated from aqueous solutions of their salts using an aqueous solution of the ammonium salt of N-β-napthyl malonamic acid. The results have been found to be very good. N/30 solutions of the metal salts give the best results. Separation and quantitative estimation of Zinc and Manganese have been done using the same organic reagent.

ESTIMATION OF NICOTINE IN SOME COMMON TOBACCO AND SMOKES*

By Dr. S. P. Mathur, M. B., M. S. *Department of Ophthalmology, Medical College, Agra.*

Most of the investigation on the estimation of nicotine in tobacco and tobacco smoke have been made in Germany, and very little on the various brands commonly marketed in India. The present investigation is a part of one intended to find out some of the effects produced on the human retina by the use of such brands.

Gedeon and Goswami (1952) reported nicotine content in tobacco waste obtained from the tobacco leaf from various parts of India. Winterstein and Aronson (1928) estimated nicotine in tobacco smoke, and found that the main current from the cigarette carries about 25 per cent of the nicotine in the tobacco, while at least 50 per cent passes into the air. The remaining 25 per cent is decomposed to nitrogenous products. From a cigar 60 per cent of nicotine appears in the smoke. The harm caused by smoking, according to van Lecuman, does not depend on a cigar being mild or strong, or on its colour, or even on the quantity of nicotine in the tobacco, but on the direct content of nicotine in smoke. It has been shown that the effect of smoking in terms of increase in blood pressure is in direct proportion to the nicotine content in smoke.

Kavalenko (1931) has stressed the time factor. When tobacco is burnt by an uninterrupted air current, about 10 per cent of nicotine in tobacco is lost. Rapidly burning cigarettes (9 to 10 minutes against 17 to 20 minutes) give twice as much nicotine in smoke as slow burning ones. Ladislans Barta and Ernst Toole (1932) found that, for the burning period of 9 and 5 minutes respectively, 49.6 and 87.4 per cent of the nicotine in the tobacco passed on in the main stream of smoke.

Kavalenko (1931) further stressed that increase from 9 to 11 per cent in the moisture content of tobacco increases the nicotine content in smoke while a further rise in moisture decreases it.

Adolf Wenusch (1934) found that the amount of nicotine passing unchanged in smoke varies with the rate of smoking. In burning without suction 45 per cent of nicotine was recovered from the smoke. With intermittent suction, as in normal smoking, 25 per cent was in the main smoke stream; and 14 per cent in the secondary stream from the burning end. However, with a rapid continuous suction the corresponding figures were 80 and 3 per cent respectively.

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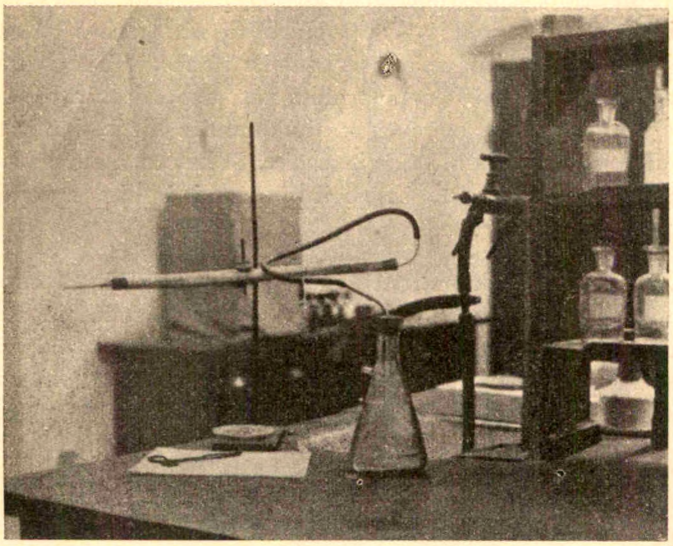
*Work conducted under the Research Fellowship of Indian Council of Medical Research.

METHODS AND MATERIAL

For estimation of nicotine in tobacco leaf, Toth's method (1901) was preferred owing to its simplicity, efficiency, and the minimum time taken. The method consists in taking 6 gm. of dried tobacco powder (heated at 60° C for three hours) in a mortar with 10 cc. of 20 per cent NaOH solution, and working into this paste enough plaster of Paris to produce a dry mass which will not 'bind' when pressed into a lump. After putting this mixture into a well stoppered bottle 60 cc. of ether and 60 cc. of petroleum ether are added to it. The bottle is shaken for an hour at intervals of 5 minutes each. 20 cc. of this ether solution is drawn off, and to it 50 cc. of water, 20 cc. of N/10 H_2SO_4 and a drop of ideosine solution are added. The mixture is titrated with N/10 KOH solution. For estimation of nicotine in tobacco smoke, following method has been employed in the present study:—

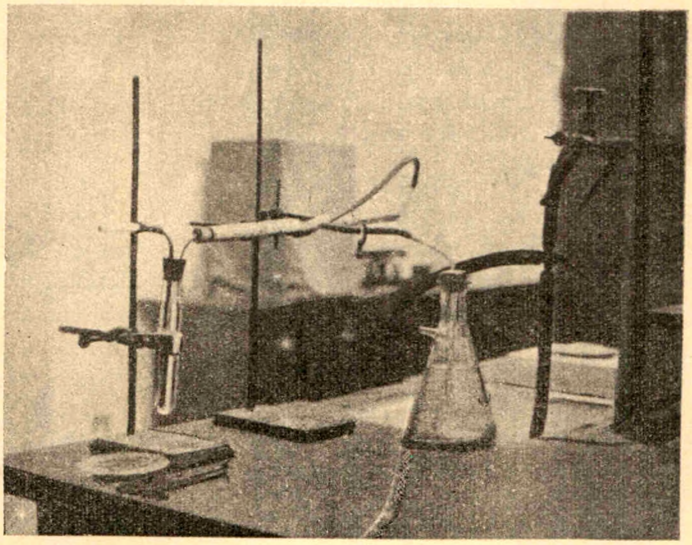
The apparatus is shown in Text-fig. 1 in working order. The smoke is absorbed in a glass tube about 24 inches long (in order to ensure a complete absorption of nicotine in the tube), packed with glass wool, and moistened with 2N H_2SO_4. A constant suction was applied at the other end of the tube after letting the air bubble through water so as to regulate the speed of suction. The rate of suction was so adjusted that a cigarette would take about 15 minutes to burn, leaving a butt of about 1.5 to 2 cm. The nicotine—H_2SO_4 is washed out with a mixture of alcohol and hot water (1:1) till the glass wool loses all its brown stain. The solution is made alkaline with 2N NaOH, and steam distilled for about half an hour till no nicotine is detectable in the solution of the distilling flask—that is, the solution does not give precipitate with Mayer's



Text-fig. Set-up of apparatus for estimation of nicotine in cigarette smoke.

reagent. The distillate is then treated with a solution of picric acid and left overnight. Nicotine is precipitated as dipicrate, which is separated by filtration and distilled after making alkaline. The distillate thus obtained is titrated with 0.01 N HCl using methyl red as indicator.

To represent 'Hookah' arrangement* a test tube containing distilled water was introduced so that the smoke had to bubble through this before it was absorbed in the tube containing glass wool (Text-fig. 2).



Text-fig. 2. Set up of apparatus for estimation of nicotine in cigarette smoke after passing it through water as in 'Hookas'.

Results

A few standard samples of Indian tobacco were procured from the Director, Central Tobacco Research Institute, Rajahamundry, S. I., and for each sample six estimations were performed. The following results give the average value:

Cigar tobacco	— 3.25 per cent of Nicotine.
Chewing tobacco	— 4.13 ,, ,, ,, ,,
Bidi tobacco	— 8.10 ,, ,, ,, ,,
Harrison special tobacco	— 3.05 ,, ,, ,, ,,
Lanka tobacco	— 7.40 ,, ,, ,, ,,

Well known market brands of tobacco were then purchased and their nicotine content estimated. The following results give an average value for six estimations.

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*A method of smoking commonly used in Northern India.

Bidi-'Pehalwan Chap'	—	4.32	per cent
'Bidi No. 27'	—	4.173	" "
Cigarettes —'Scissors'	—	1.71	" "
'du-Maurier' filter fitted	—	1.94	" "
'Craven—A'	—	2.175	" "
Cigar—'Trichinopoly'	—	2.068	" "
Pipe tobacco—'Capstan—Navy Cut' medium strength	—	3.013	" "
Snuff tobacco—'Hulas'	—	2.639	" "
Chewing tobacco—'Banarsi'	—	2.79	" "
'Sahajahanpuri	—	2.006	" "
Hookah tobacco (local made, Agra)	—	1.64	" "

'Scissors' cigarette was selected for finding nicotine in its smoke. This was done to get an approximate idea of the percentage of nicotine escaping in the main stream of the smoke. In all, twenty one estimations were made and an average value of the six most concurrent readings was calculated. It was found that 4.45 mgm. of nicotine could be recovered from the smoke of one cigarette, which came to 24.7 per cent of the nicotine in its tobacco.

The effect of filter in the filter fitted du-Muaurier cigarette was then investigated. It was found that only 8.66 per cent of nicotine in its tobacco could be recovered from the smoke.

With the 'hookah' arrangement it was found that 6.2 per cent of the nicotine could be recovered from the water; while only 1.2 per cent could be recovered from the smoke afterwards. It is thus evident that about 17.3 per cent of nicotine is lost by smoking tobacco in this way. In an actual 'hookah' much longer tubes, as well as a larger quantity of water are used than those in the present experiment. It is, therefore, evident that the quantity of nicotine passing over would also be much less.

CONCLUSION

Tobacco of the market brands of 'bidis' contain about 4 per cent. nicotine, cigarette tobacco about 2 per cent, cigar tobacco 2 per cent, pipe tobacco 3 per cent, snuff tobacco 2 per cent, chewing tobacco about 2 per cent and hookah tobacco about 1.5 per cent. The main stream of smoke from an ordinary cigarette contains about 25 per cent of nicotine in tobacco, while that of a filter tipped cigarette, only 8 per cent. Thus from the point of view of nicotine content in tobacco and its smoke, chewing is the most harmful method of consuming tobacco. Similar may be the case with snuff, in which tobacco particles get deposited over the nasal mucosa, so that their toxic products get absorbed. After this, in decreasing order of toxicity, come Bidi, cigar, pipe, and cigarettes. Amongst the cigarettes, the filter-tipped are less harmful than the ordinary types. Unfortunately they are too costly to suit every pocket. In ordinary cigarette smoking, smoke will be rendered less harmful if long adapters of a material that is poor conductor of heat were to be used, most of the nicotine, carbon, and other organic matter would get deposited on the walls of the adapter. Similarly, though the pipe tobacco contains more of nicotine, the smoks will be lass harmful if longer pipes are used. Some of the pipes have a filter arrangement which further reduces the toxic content of smoke as it has to pass through a longer zig-zag course.

"Hookah' seems to be the least harmful of all the methods of consuming tobacco. The long wooden tubes absorb a large portion of nicotine, and the various toxic products get condensed on their walls. Moreover, the smoke has to pass through water which still further reduces the toxicity and allows nicotine to pass over in negligible amount. But as the equipment and method of preparation of a 'hookah' is very elaborate and time consuming, it is losing popularity, while cigarettes and Bidis are taking its place.

SUMMARY

1. Nicotine content of the various brands of common tobacco, consumed in various ways is estimated.

2. Nicotine content of the main stream of smoke of a lighted cigarette has been ascertained. The effect of filter in the filter fitted cigarettes has also been damonstrated as a potent agent in reducing the nicotine content of smoke.

3. Effect of passing the smoke through water as in a 'hookah' has been found to be most effective in reducing the nicotine content of tobacco smoke.

ACKNOWLEDGEMENT

I am grateful specially to Dr. P. I. Ittyerah, Professor of Chemistry, St. John's College, Agra, who provided me with various facilities for the present work. Thanks are also due to Dr. J. Gedeon, Mr. N. Ram, Dr. N. Ghatak, Dr. M. V. George, and Mr. P. P. Bagchi for a great deal of help as well as to the Director, Central Tobacco Research Institute, Rajahamundry, S. I. for the supply of various standard samples of Indian tobacco.

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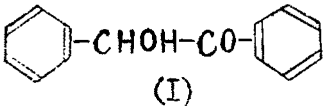
OPPENAUER OXIDATION OF BENZOINS TO BENZILS

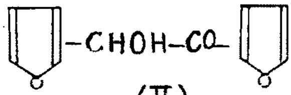
By R. N. Gupta and S. S. Deshapande, *Chemistry Department, Holkar College, Indore.*

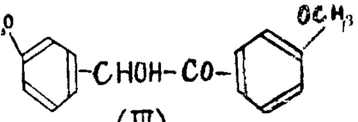
Benzoins could be oxidised to benzils with copper sulphate in pyridine in high yield though the products are always contaminated with unchanged benzoins.[1]

RCHOH-COR (BENZOIN)	Copper Sulphate	RCO-COR (BENZIL)

As benzoins contain a secondary alcoholic group, Oppenauer Oxidation could be conveniently employed for their conversion into benzils.[2] The product is free from the unchanged benzoin and even without the necessity of any crystallisation gives negative test with Fehling's solution. In this laboratory Oppenauer-Oxidation has been successfully tried with Benzoin (I), Furoin (II), and Anisoin (III).


(I)


(II)



(III)

The customary aluminium tertiary butoxide could be replaced by aluminium-phenoxide, which is both convenient to prepare and efficient to work. This method of oxidation of benzoins is definitely superior to copper sulphate pryridin method, if the time for completion of reaction is not of any moment.

Experimental

2 gms. of benzoin was taken in 500 ml. R.B. Flask, 200 ml. of dry acetone and 200 ml. of dry benzene were added. This was refluxed with 4 gms. of aluminium phenoxide for 15 hours with the exclusion of moisture. The acetone was recovered by distillation. The contents of the flask were shaken with 50 ml. of dil HCl, the benzene layer separated, washed with 50 ml. of 10% sodium carbonate and finally with water. After drying over fused calcium chloride and distilling off the solvent, a liquid was left which after vigorous stirring with 50% Et OH, gave benzil as a yellow solid. It was filtered at the pump and dried. The filterate was diluted with water and allowed to stand overnight, when a further crop of benzil was obtained.

Total Yield=1·6 gms. (80%).

The melting point of the product was found to be 95° and was not depressed after mixing with authentic specimen of purebenzil. The melting point of 2 : 4 dinitro phenyl hydrazone was found to be 189° which is identical with that recorded in literature. The product did not reduce Fehling's solution (absence of benzoin). Furil and Anisil were obtained in a similar manner from furoin and Anisoin respectively.

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[1] Clark & Drager. Org. Synth. Coll. Vol. I, Page 87.

[2] Carl Djerassi. Oppenauer Oxidation Organic Reactions Vol. VI. page 207.

LABORATORY ASSAY OF CERTAIN FUNGICIDES, ANTIBIOTICS AND SULPHA-DRUGS ON THE GERMINATION OF CHLAMYDOSPORES OF *PROTOMYCES MACROSPORUS* UNG.

By J. S. Gupta, *Botany Department, Agra College, Agra.*

Introduction

During the past twenty years the method of testing chemicals in the laboratory for their fungicidal property by studying their effect on the germination of fungal spores under controlled conditions has been found to be fairly reliable criterion for predicting the behaviour of fungicides under field conditions. Researches on these lines have greatly facilitated the production of a large number of versatile commercial preparations for the control of plant diseases. These preliminary laboratory tests are helpful in eliminating inactive compounds or even for comparing the activities of different compounds under identical conditions.

A farily extensive literature has accumulated in recent years on the subject of assaying fungicides and other chemical compounds by noting the inhibition of spore germination. Radoni and DiCaro (1954) from their studies on the effect of oxychlorides with varying proportions of copper and calcium on the germination of conidia of *Alternaria tenuis* concluded that biological value of copper components varies according to the chemical structure of the compounds. Frick (1955) observed that 8-hydroxy-quinoline, phenylmercuric chloride, captan and thiram were most effective fungicides in inhibiting spore germination of *Botrytis cinerea.* The spores of *Ramularia sp.* and *Botrylis cinerea* were killed at 50 and 100 pp.m. of actidione depending on the temperature and PH of the solutions (Thanos, 1954).

Gassner (1953) noted suppression of germination of wheat bunt (*Tilletia brevifaciens*) in tritisan at 150 and 200 gm per Kg. Kono (1954) observed the inhibiting effect of four sulphanilamides on *Fusarium cepae* where germination was reduced to 50% at 28° C in a 10^{-2} M. solution of aceto-sulphanile.

Protomyces macrosporus Ung. causes hypertrophy in stem, leaves, inflorescence and fruits of coriander. The author (1954) estimated a mean loss of 15% per plant in yield of fruits with a mean disease intensity of 23% in a cultivator's field at Gwalior. The disease perpetuates through soil or seeds, the spores being externally seed borne. This opens up the possibility of controlling the disease by fungicides of known fungistatic property on the germination of the chlamydospores of the parasite.

METHOD AND MATERIAL

Rideal-Walker's method (McCallan, 1947) of evaluating antiseptics with some modifications was followed. The treatment included two sulphadrugs (sulphathiazole and sulphadiazine), two antibiotics (penicillin and streptomycin), two fungicides (perenox and agrosan) and distilled water. The chemicals in the three groups were used at 250, 500 and 1000 ppm. Heavily infected fruits of coriander collected in the previous year, were surface sterilised in 0.1% mercuric chloride solution for one minute and washed repeatedly with sterile distilled water. The infected fruits were crushed in sterile distilled water and the mixture was filtered through a sterilized muslin piece so as to allow chlamydospores to pass through. 7-8 drops of the filterate, each containing 20-40 chalamdospores were placed on a slide in a linear row. The drops were allowed to dry up leaving the spores sticking to the slide. The slides were then transferred to coplin jars containing solutions of the different fungistatic substances and stored in a cabinet with a temperature range of 18-20° C. The solutions in the coplin jars were changed on alternate days to avoid bacterial contamination.

Observations on germination of chamydospores in 15 drop cultures were made for each treatment on alternate days under the low power of the microscope upto the 9th day. Counts of germinated and ungerminated spores were noted from the 5th day onwards because no germination occured prior to this. The results were analysed statistically following the analysis of variance method. The degrees of freedom are:

Chemicals	6
Concentrations	3
Interaction	18
Residual	257
Total	284

RESULTS

The data on the effect of chemicals, dosage and their interactions are summarised in tables I, II & III respectively and also represented by graphs (Figs. 1, 2 & 3).

Table I

Effect of sulpha-drugs, antibiotics and fungicides on percentage inhibition of germination of chlamydospores.

(Mean of 45 values with 15 replications and 3 concentrations.)

Chemicals	Days		
	5th day	7th day	9th day
Distilled water (control) (Mean of 15 values)	92.0	63.5	35.8
Sulphadiazine	100.0	96.3	88.3
Sulphathiazole	97.8	93.7	90.6
Penicillin	93.0	64.7	45.8
Streptomycin	100.0	100.0	99.8
Perenox	100.0	100.0	99.8
Agrosan	100.0	100.0	99.9
C.D. at 5 % level	1.29	1.66	6.50

Irrespective of the dosage, the percentage of ungerminated chlamydospores in penicillin was not significantly different from the control in the early stages (upto 7th day) but on the 9th day it was 10% more than in the control

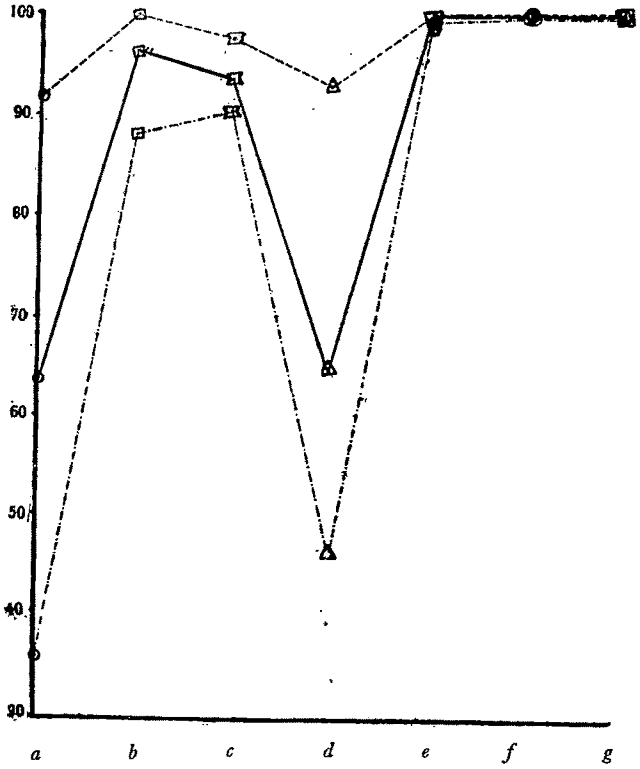

Fig. 1. Influence of chemicals on inhibition of Chlamydospores germination in *Protomyces macrosporus* Ung.
a : Distilled water (control); *b* : Sulpha-diazine; *c* : Sulpha-thiazole; *d* : Penicillin; *e* : Streptomycin; *f* : Perenox *g* : Agroson.
—.—.—: 5th day; ——: 7th day; — — — — —: 9th day.

as is evident from table 1 and Fig. 1 The rest of the chemicals used, however, suppressed germination almost completely The inhibition in streptomycin, perenox and agrosan was more than in sulphathiazole and sulphadiazine.

Table II

Effect of concentrations of chemicals on percentage inhibition of germination of chlamydospores.

(Mean of 90 values with 15 replications and 6 chemicals)

Chemicals	Days		
	5th day	7th day	9th day
Distilled water (control) (Mean of 15 values)	92.0	63.5	35.8
250 ppm.	95.9	84.0	78.6
500 ppm.	99.5	93.6	88.6
1000 ppm.	100.0	99.4	94.0
C.D. at 5% level	0.92	1.18	5.0

The above data as well as the curves in fig. 2 show the relative effect of three concentrations studied in the present investigation on germination of

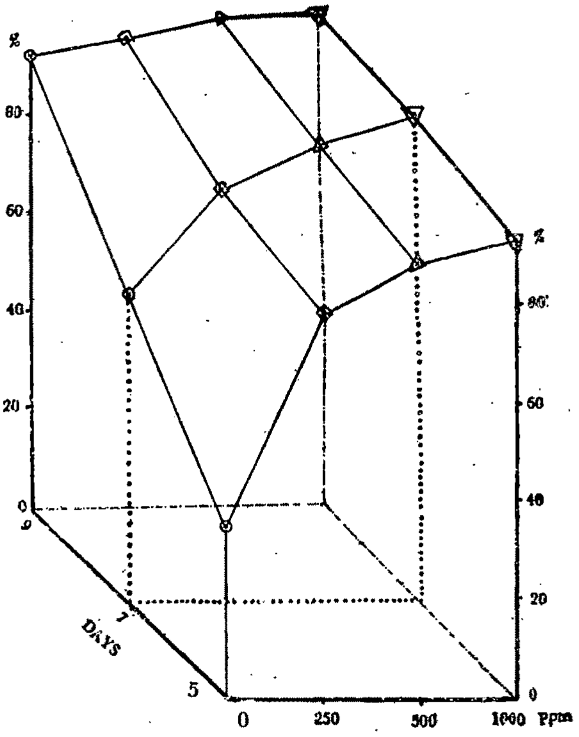

Fig. 2. Influence of dosage on inhibition of Chlmydospore germination in *Protomyces macrosporus* Ung.

chlamydospores. The inhibition of chlamydospore germination enhanced with the higher doses of the chemicals, being highest in 1000 ppm. (94.0%) and fairly high in 250 ppm. (78.6) as compared to the control (35.8).

Table III

Interaction between various treatments on percentage inhibition of germination of chlamydospores.

(Mean of 15 values)

Treatments	Days		
	5th day	7th day	9th day
Distilled water	92.0	63.5	35.8
Sulphadiazine			
250 ppm.	100.0	90.6	70.6
500 ”	100.0	98.9	92.5
1000 ”	100.0	99.5	98.4
Sulphathiazole			
250 ppm.	95.3	91.1	89.3
500 ”	98.0	92.1	89.6
1000 ”	100.0	98.3	93.1
Penicillin			
250 ppm.	79.6	29.4	14.3
500 ”	99.3	70.9	50.3
1000 ”	100.0	98.7	72.8
Streptomycin			
250 ppm.	100.0	99.3	98.1
500 ”	100.0	100.0	99.4
1000 ”	100.0	100.0	100.0
Perenox			
250 ppm.	100.0	100.0	97.7
500 ”	100.0	100.0	98.8
1000 ”	100.0	100.0	100.0
Agrosan			
250 ppm.	100.0	100.0	99.0
500 ”	100.0	100.0	100.0
1000 ”	100.0	100.0	100.0
C.D. at 5% level	2.24	2.88	10.8

A close examination of values for the interaction (Fig. 3) 'chemicals × doses' reveals the differential behaviour of the chemicals in the three concentrations. The three columns representing each treatment in Fig 3 give values for the 5th, 7th, and 9th day respectively. Different doses of sulphadiazine gave the same amount of inhibition of chlamydospores germination upto the 5th day but the dose-effect became evident on the 7th day, when 500 or 1000 ppm. of sulphadiazine significantly increased the inhibited percentage of chlamydospores as compared to 250 ppm. and this trend continued till the 9th day. Differences in inhibition percentage of chlamydospores due to concentrations in sulphathiazole were apparent on the 5th day as well as on the 7th day but were not obvious on the 9th day. On the 5th day the inhibition percentage was maximum (100%) with 1000 ppm.

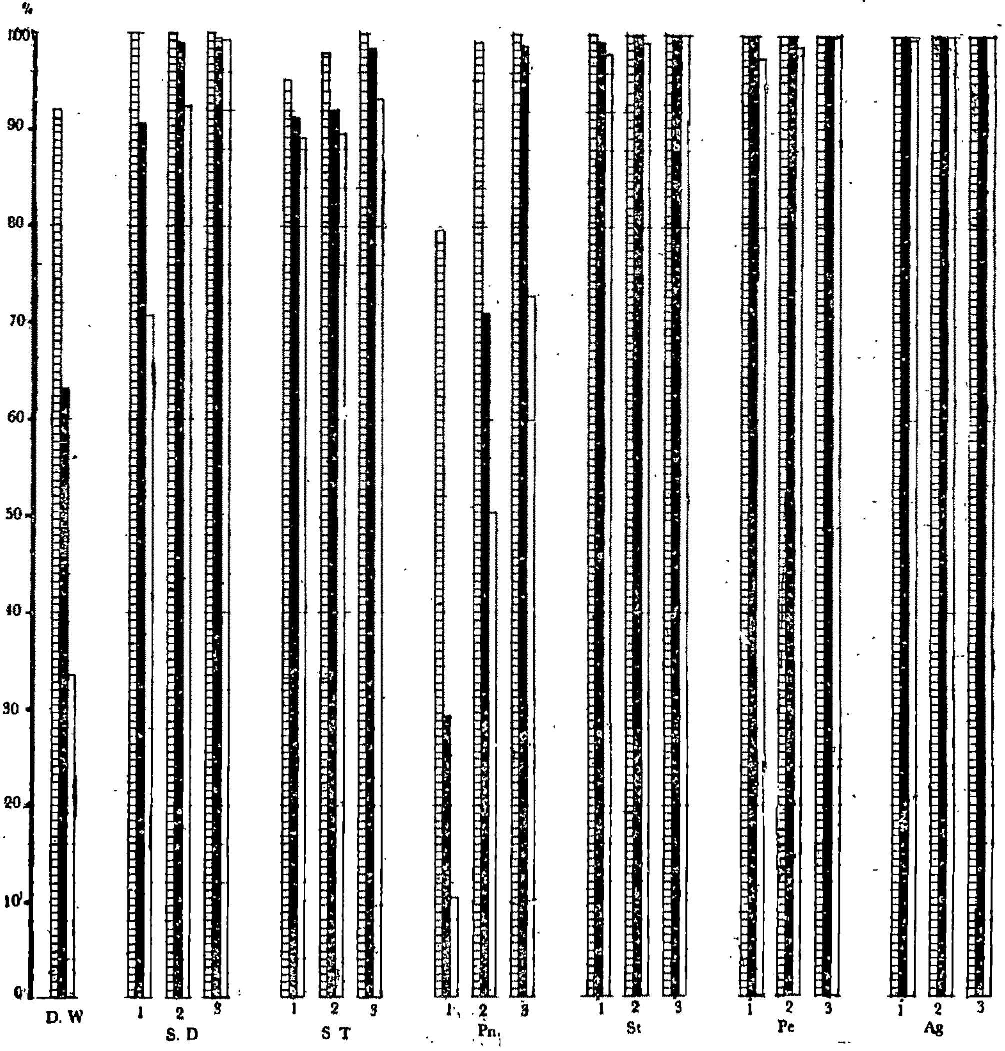

Fig. 3. Influence of different dosages of various chemials on inhibition of Chlamydospore germination in *Protomyces macrosporus* Ung.

D. W. : Distilled water (control); S. D. Sulpha-diazine;
S. T. : Sulpha-thiazole; Pn: Penicillin; St. Streptomycin;
Pe: Perenox; Ag: Agrosan.
1 : 250-ppm.; 2 : 500-ppm.; 3 : 1000-ppm.

of sulphathiazole and significant decline was observed in 250 ppm. alone (95.3%) while reduction in inhibition was obtained both with 250 (91.1%) of 500 ppm. (92.1%) of the drug on the7th day.

The dose-response in penicillin was distinct from the beginning and continued like that till the end. It, however, loses its efficiency more rapidly than the others. Streptomycin did not exhibit any variation in inhibition of germination due to the concentration.

Both the fungicides (perenox and agrosan) did not indicate any dose-response effect. Even the lowest dose resulted in almost total suppression of chlamydospore germination.

SUMMARY

Effect of O, 250, 500 and 1000 ppm. solutions of a few sulpha-drugs (sulphadiazine and sulphathiazole), antibiotics (penicillin and streptomycin) and fungicides (agrosan and perenox) has been investigated on the inhibition of chlamydospore germination of *Protomyces macrosporus* Ung. using a modification of Rideal-Walker's method of evaluating antiseptics.

Sulphathiazole and Sulphadiazine showed effective inhibition of germination. Penicillin, was effective only in the highest dose (1000 ppm.) Streptomycin, agrosan and perenox inhibited germination almost completely.

Tables and graphs showing the effect of the chemicals, dosage response and their interactions are presented.

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STUDIES ON THE VELOCITY OF FLOW OF SOLVENTS THROUGH CHROMATOGRAPHIC COLUMNS: PART IV—EFFECT OF THE GRADATION OF THE SIZE OF THE PARTICLES ON THE VALUES OF THE CONSTANT, $\frac{vh}{t} \times \frac{n}{d}$ DERIVED FROM THE RATE OF FLOW OF LIQUIDS THROUGH THE ADSORBENT COLUMNS.

By D.R. Gupta M.Sc., *Asstt. Professor of Chemistry, D.S.B. Govt. College, Nainital,*
and
Abani K. Bhattacharya D.Sc. F.R.I.C. *Professor of Chemistry, Agra College, Agra.*

In our previous communications (1954, 1955) we reported our observations on the velocity of flow of pure organic liquids through different adsorbent columns packed in the same Chromatographic tube. It was shown that when liquids of the same homologous series are made to flow through the columns packed with the same graded size of the adsorbent particles under a constant suction pressure, the value of the expression $\frac{v\,h}{t} \times \frac{n}{d} = K$ (Constant), where v=volume of the liquid flowed out in time t, h, the height of the column kept constant in every case, n, the viscosity of the liquid and d, its density. The values of the constant calculated by this formula were, however, different for the family of different homologous series. This evidenced the important role of the structural characteristics of liquids and adsorbents in determining the velocity of flow through packed columns.

In our previous communications (Loc. cit) the adsorbent columns wer prepared of such particles of the adsorbents which had only been passed through a 60 mesh sieve. Since the pores of the column are undoubtedly governed by the size of the particles, it was considered interesting to study the effect of a more restricted grading of particles on the flow of liquids. The particles used in making the columns in the present study correspond to the sizes—(i) 60-80 mesh (ii) 80-100 mesh and (iii) 100-120 mesh. The interesting observations on the rate of flow of the liquids, when they are made to flow through columns made of particles of different grades, have been elicited in this paper.

EXPERIMENTAL

In determining the velocity of flow of the liquids through the packed columns every care was taken to draw the liquids under a constant suction pressure and room temperature under uniform conditions of the surroundings. The three grades of the adsorbent particles i.e. (i) 60-80 mesh, (ii) 80-100 mesh (iii) 100-120 mesh were prepared, with the help of standard sieves (Andhra Scientific Works). Each grade of the adsorbent was stirred thoroughly in the solvent and warmed. to expel the dissolved air, if any. The chromatographic tube having a bed of asbestos wool of constant thickness over the porcelain sieve at the bottom was uniformly packed as far as possible, by manipulation as described in part I (Gupta and Bhattacharya, 1953). The solvent was made to flow under a constant suction force by the same arrangement as explained in part II (1954). The volume V in c.c. of the solvent flown in time (t) was noted. The height (h) of the column was determined by means of a cathetometer, the density of the liquid by means of a pyknometer and the viscosity by an ostwald viscometer. Having determined v, h, and d, it was possible to calculate the

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values of vh/t and $\frac{vh}{t} \times \frac{n}{d}$ in each case.

For the determination of porosity, the true and apparent densities of the adsorbent particles were calculated (Knowles and Watkins, 1947). For determination of the true density, a 50 c.c. specific gravity bottle was weighed empty, and it was weighed again when filled with distilled water. 5 gms. of dry adsorbent were weighed into a small beaker, and boiled for some time with a few ml. of the liquid in order to expel air. The adsorbent was transferred to the S.G. bottle and filled with the liquid and it was allowed to cool to room temperature and weighed. The weight of the liquid displaced by 5 gms. of the adsorbent was determined and true density of the adsorbent was obtained by dividing the weight of the adsorbent taken by the weight of the liquid displaced by it. This was multiplied by the density of the liquid to obtain true density of the adsorbent with respect to water. For determination of the apparent density, the S.G. bottle was packed with the adsorbent upto a certain mark. Several readings were taken. Weight of water required to fill the bottle upto the same mark was also noted. Weight of the adsorbent divided by weight of water gives apparent density. The porosity (by volume) is then calculated by the following formula:—

$$\frac{\text{True density—apparent density}}{\text{True density}} \times 100$$

TABLE I

Adsorbent—$CaCO_3$

Height of the mercury in the monometer 36 cms.
Temperature of the experiment. 20° C. 10

Name of the liquids	Size of particles.	Vol. v in Sec.	Time t in cms.	Height h [100xm)	Viscosity	Density d	yh	Vhx of k
1	2	3	4	5	6	7	8	9
Benzene	60 to 80	2.5	123.2	4.638	.6421	.8780	.0941	.0688
,,	80 to 100	,,	110.0	4.625	,,	,,	.1051	.0768
,,	100 to 120	,,	96.5	4.641	,,	,,	.1202	.879
Toluene	60 to 80	,,	112.0	4.620	.5802	.8690	.1032	.0638
,,	80 to 100	,,	98.0	4.610	,,	,,	.1173	.0785
,,	100 to 120	,,	90.0	4. 02	,,	,,	.1278	.0854
Xylene	0 to 80	,,	140.0	4. 92	. 881	.8618	.0838	.0669
,,	80 to 100	,,	120.0	4.608	,,	,,	.0932	.0784
,,	100 to 120	,,	4.586	,,	,,	.1124	.1124	.0897
Acetone	60 to 80	,,	100.0	4.526	.3301	.7890	.1131	.0473
,,	80 to 100	,,	95.2	4.658	,,	,,	.1210	.0506
,,	100 to 120	,,	93.0	4.596	,,	,,	.1415	.0592
Methyl	60 to 80	,,	126.0	4.570	.4200	.8050	.0907	.0473
ethyl	80 to 100	,,	108.0	4.562	,,	,,	.1056	.0551
	100 oto 120	,,	109.0	4.932	,,	,,	.1119	.0584
Methlyl	60 to 80	2.5	130.5	4.608	.3720	.9268	.883	.0354
Acetate	80 to 100	,,	108.0	4.513	,,	,,	.1120	.0449
,,	100 to 120	,,	90.0	4.532	,,	,,	.1258	.0505
Ethyl	60 to 80	,,	150.5	4.657	.4410	.8962	.0074	.0381
,,	80 to 100	,,	128.8	4.632	,,	,,	.0893	.0442
,,	100 to 120	,,	112.8	4.693	,,	,,	.10441	.0512
Acetate								
n-Propyl	60 to 80	,,	219.0	4.826	.5723	.8820	.0551	.0358
Acetate	80 to 100	,,	170.0	4.532	,,	,,	.6660	.0432
,,	100 to 120	,,	157.0	4.688	,,	,,	.0746	.0484
n-Butyl								
Acetate	60 to 80	1.0	112.4	4.622	.7912	.8790	.0411	.0370
,,	80 to 100	,,	96.4	4.625	,,	,,	.0478	.0431
,,	100 to 120	,,	79.8	4.523	,,	,,	.0567	.0510
Carbon	60 to 80	2.5	130.0	4.582	.9580	1.5950	.0381	.0529
tetra-	80 to 100	,,	120.0	4.484	,,	,,	.0934	.0561
chloride	100 to 120	,,	119.3	4.503	,,	,,	.0946	.0568
Cyclo-	60 to 80	,,	110.0	4.555	.9752	.7790	.1033	.1381
,,	80 to 100	,,	93.2	4.523	,,	,,	.1213	.1620
,,	100 to 120	,,	89.2	4.611	,,	,,	.1292	.1724

TABLE II

Adsorbent—(MgO).

Height of the mercury in the monometer — 36 cms.
Temperature of the experiment — 20°C.±05°C

Name of the liquids.	Size of particles.	Vol. V in ml.	Time t in sec.	Height h in cms.	Viscosity (100 x)	Density.	$\frac{vh}{t}$	$\frac{vh}{t} \times \frac{n}{d}$
1	2	3	4	5	6	7	8	9
Benzene	60 to 80	2.5	163.4	4.558	.6421	.8780	.0699	.0511
,,	80 to 100	,,	160.4	4.597	,,	,,	.0716	.0524
,,	100 to 100	,,	155.0	4.508	,,	,,	.0728	.0532
Toluene	60 to 80	,,	154.0	4.704	.5802	.8690	.0764	.0510
,,	80 to 100	,,	146.0	4.566	,,	,,	.0782	.0521
,,	100 to 120	,,	144.0	4.656	,,	,,	.0808	.0539
Xylene	60 to 80	,,	171.0	4.431	.6881	.8618	.0648	.0518
,,	80 to 100	,,	177.0	4.660	,,	,,	.0658	.0526
,,	100 to 120	,,	166.4	4.526	,,	,,	.0680	.0543
Acetone	60 to 80	,,	115.0	4.621	.3301	.7890	.1004	.0420
,,	80 to 100	,,	112.8	4.638	,,	,,	.1028	.0430
,,	100 to 120	,,	102.5	4.616	,,	,,	.1126	.0471
Methy Ethyl Ketone	60 to 80	,,	145.2	4.745	.4200	.8050	.0817	.0426
,,	80 to 100	,,	144.0	4.792	,,	,,	.0832	.0434
,,	100 to 120	,,	136.5	4.714	,,	,,	.0856	.0444
Methyl Acetate	60 to 80	,,	140.2	4.665	.3720	.9268	.0832	.0334
,,	80 to 100	,,	126.0	5.623	,,	,,	0917	.0368
,,	100 to 120	,,	110.0	4.631	,,	,,	.0965	.0388
Ethyl Acetate	60 to 80	,,	165.0	4.531	.4410	.8952	.0686	.0338
,,	80 to 100	,,	157.0	4.606	,,	,,	.0748	.0368
,,	100 to 120	,,	143.0	4.631	,,	,,	.0782	.0385
Prophyl Acetate	60 to 80	,,	233.0	4.676	.5723	.8820	.0502	.0326
,,	80 to 100	,,	210.0	4.697	,,	,,	.0558	.0362
,,	100 to 120	,,	197.0	4.649	,,	,,	.0590	.0383
Carbon Tetra-Chloride	60 to 80	,,	254.8	4.598	.9580	1.5950	.0451	.0271
,,	80 to 100	,,	254.0	4.727	,,	,,	.0465	.0280
,,	100 to 120	,,	241.0	4.631	,,	,,	.0480	.0283
Cyclo-hexana	60 to 80	,,	271.0	4.617	.9752	.7790	.0426	.0558
,,	80 to 100	,,	253.5	4.640	,,	,,	.0457	.0610
,,	100 to 120	,,	218.5	4.817	,,	,,	.0531	0.708

TABLE III

Porosity of MgO.

Solvent.	Size of the particles.	True Density d	Apparent density d_1	Porosity $\frac{d-d_1}{d} \times 100$
1	2	3	4	5
Water	60 to 80	2.884	.886	69.29
,,	80 to 100	2.805	.840	70.04
,,	100 to 120	2.869	.826	71.17
Benzene	60 to 80	2.815	.816	68·53
,,	80 to 100	2.735	.840	69.29
,,	100 to 120	2.806	.826	70.56
Toluene	60 to 80	2.646	.886	66.51
,,	80 to 100	2.561	.840	67.20
,,	100 to 120	2.632	.826	68.62

DISCUSSION

It is interesting to observe, that vh/t increases slightly as the grading of the particles becomes finer with corresponding increase in the value of $vh/t \times \frac{n}{d}$ for liquids of the same family vide column 8 of tables I and II. But, for the columns of nearly the same height and of the same grading of particles, the value of $vh/t \times n/d$ remains constant within the limits of experimental errors vide column 9 of table I and II. The velocity of flow, therefore, adjusts itself with the values of n and d to give a constant value $vh/t. \times n/d$ for the same family of compounds. It may be noted further that the constant is characteristic of the homologous family. This shows that, among other factors which govern the velocity of flow liquids through a packed column, their structures also play some significant role.

In table III it is observed that porosity increases by only 2 percent for the same liquid when the gradings of the size of the adsorbent particles are changed from 60-80, 80-100 and 100-120 mesh, the porosity being slightly greater with smaller size of the particles. This observation suggests that the pore space in the column tends to increase when layers are packed with smaller particles.

The equation $vh/t \times n/d = K$ had been derived from fundamental considerations in our previous communication (1957) in which it was shown that it is a modified form of the Darcy's Law for the velocity of flow of liquids through a porous medium. The same relation can also be derived from the

Poiseuille's equation for the flow of liquids through capillary tubes (1860), if it is assumed that the flow is vertically downwards, and the pressure, both at the top of the liquid column and in the space in which the liquid flows is the atmospheric pressure. In that case, the poiseuille's equation may be written as $V = \frac{II\,R4\ Pt}{8\ nh}$ or $\frac{vh}{t} \times \frac{n}{p} = \frac{II\,R\ 4}{8}$ where p is the hydrostatic pressure and the rest have their usual meanings.

Since $P \propto$ density $\therefore P = kd$

Hence $\frac{v\,h}{t} \cdot \frac{n}{d} = \frac{I}{k} \cdot \frac{IIR^4}{8} = K.$ (Constant.)

Further work is in progress.

CONCLUSIONS

The effect of the gradation of the size of the particles in an adsorbent column on the rate of flow of liquids has been observed. The rate of flow per unit height per unit time (vh/t) increases slightly for a certain height of column as the grade of the particles becomes smaller. The value of vh/t × n/d, however, remains constant for the membres of the same homologous series, when particles of the same grade are packed in the chromatographic columns.

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ABSORPTION SPECTRA OF α-BROMO ACETOPHENONE, α-FORMYL α-BROMO ACETOPHENONE AND p CHLORO α-FORMYL α-BROMO ACETOPHENONE.

By M. M. BOKADIA, M.Sc., Ph.D. and K. P. VERMA, M.Sc.,
D. S. B. Government College, Naini Tal.

Absorption spectrum of acetophenone has been studied by various workers. It exhibits three maxima[1] (241.5; 278. 5; and 320 mμ). α-formyl acetophenone (I; X=H; Y=H) is unstable, it undergoes self-condensation resulting in the formation of sym. tribenzoyl benzene[2]. But α-Bromo α-formyl acetophenone [3,4] (I; X=H; Y=Br), which mostly exists in the enol form is a stable compound(m. p. 106°). The authors have studied its absorption spectrum in n-Hexane. It gave three maxima at 255, 285 and 320 mμ.(Fig. 1) A comparison of the above values with the values of acetophenone cited above shows that the introduction of a formyl radical has bathochromic effect. To get still better comparison phenacyl bromide was also studied. It gave four maxima at 222, 250, 283 and 320 mμ. In this case a new band appears in the 222 mμ region.

In the case of α-bromo α-formyl p-chloro acetophenone[5] (I;X=Cl;Y=Br) three maxima have been obtained (255, 330 and 378 mμ). In this case the absorption due to phenyl group is completely absent. This may be attributed to the contributing structures II to V. (Fig. 2) [Cf. 6]

TABLE I

	λ	Emax	λ	Emax	λ	Emax	λ	Emax
I. α-Bromo α-formyl acetophenone C_6H_5 CO-CBr=CHOH	255	11,000	285	34,000	320	4600	...	...
II. α-Bromo α-formyl p-chloro-aceto-phenone. Cl·C_6 H_4-CO-CBr ‖ CHOH	255	5,600	...	...	330	1080	378	7800
III. Phenacyl Bromide C_6 H_5-CO-CH_2 Br.	250	29,000	...	...	320	840	...	...

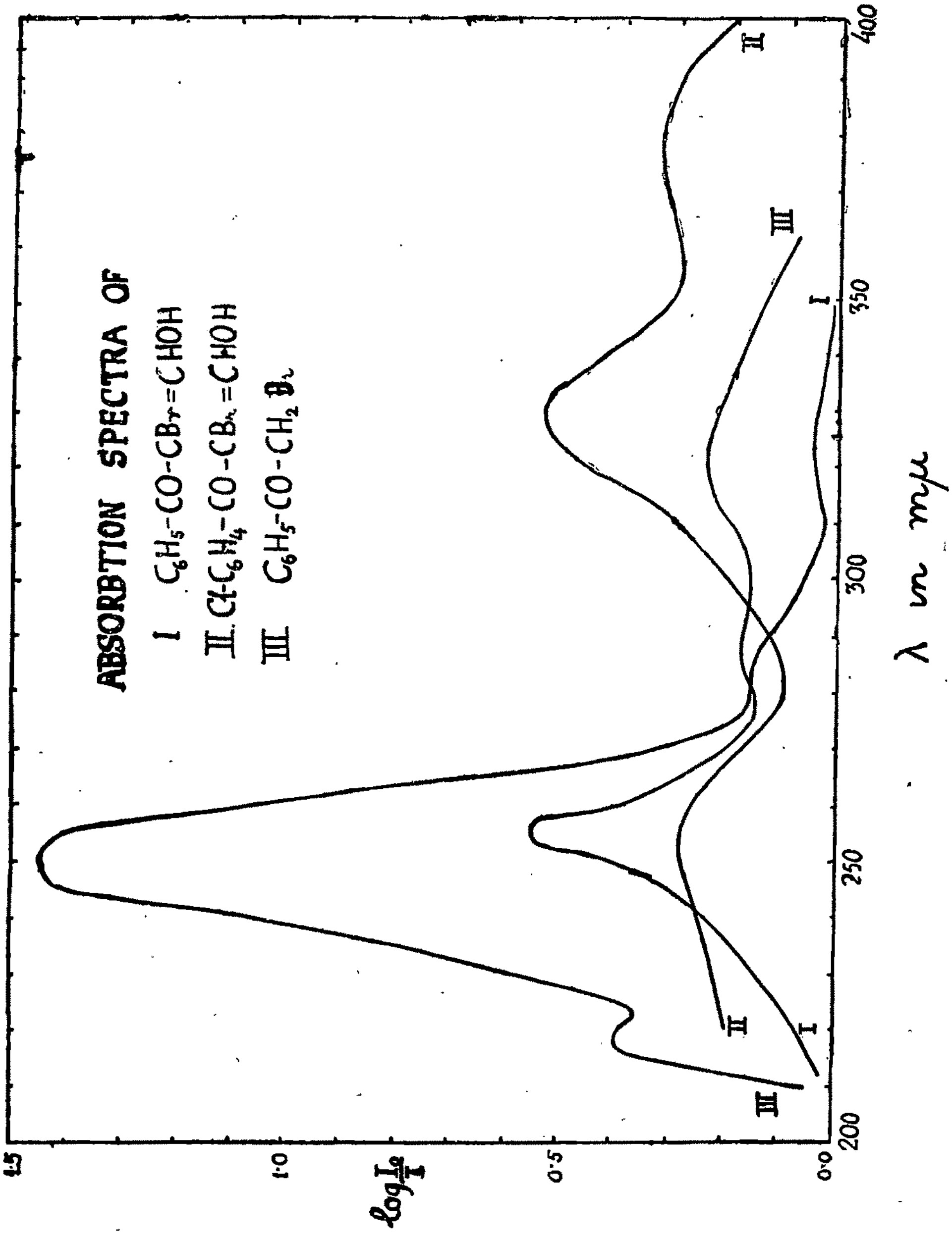
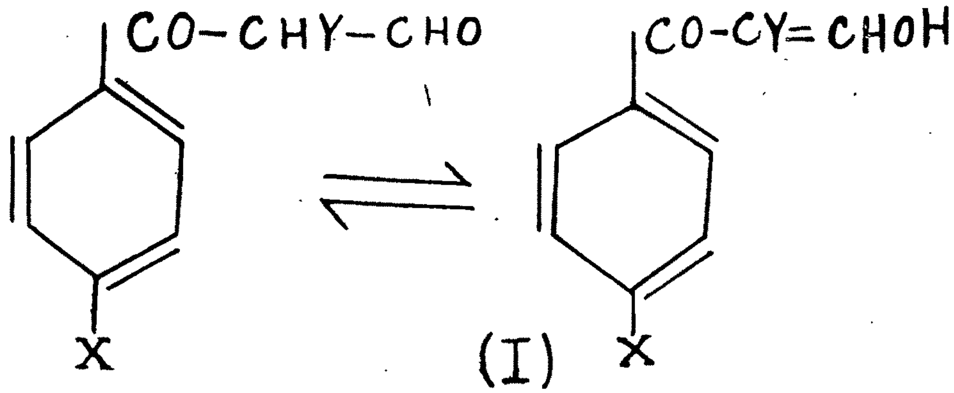

ABSORBTION SPECTRA OF
I C_6H_5-CO-CBr=CHOH
II Cl-C_6H_4-CO-CBr=CHOH
III C_6H_5-CO-CH_2Br
I
II
III
λ in mμ
200
250
300
350
400
$\log \frac{I_0}{I}$
0.0
0.5
1.0
1.5

Fig. 1.



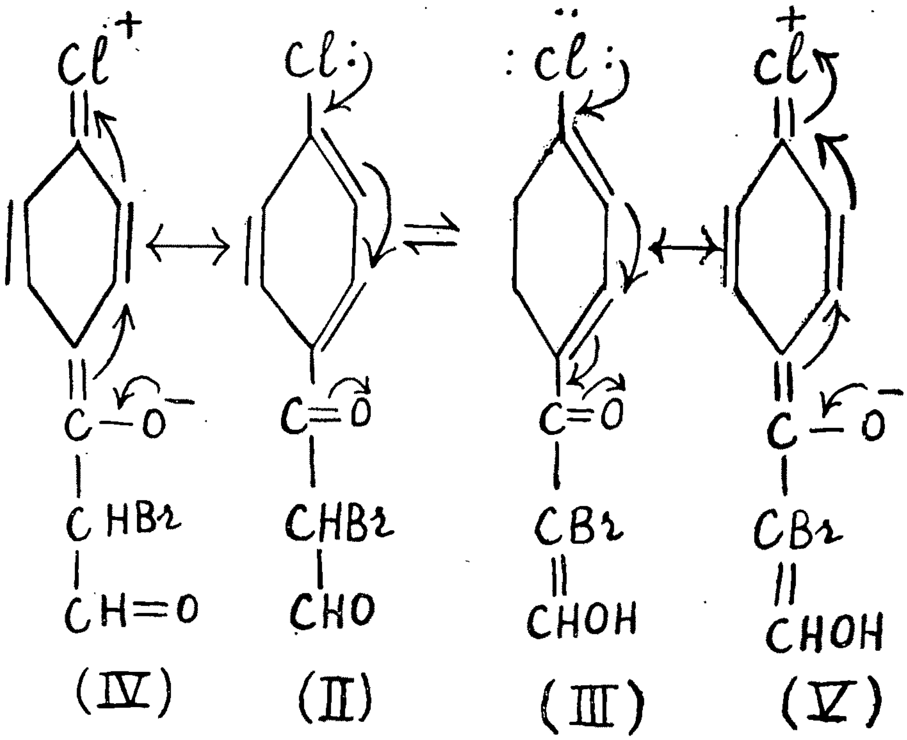


Fig. 2.

EXPERIMENTAL

Absorption measurements have been made with the Hilger 'Uvispek Photo-electric spectrophotometer'. This instrument essentially consists of a controlled light source feeding a monochromator, selected radiations from which pass through the substance under test and fall upon photo-electric cells. The e. m. f. thus produced is fed to a measuring unit where it is amplified and balanced by that from a calibrated potentiometer, whose scale is graduated in densities and transmissions. A drum engraved in wavelengths selects the spectral region for measurement. The instrument is entirely mains operated and has two optical systems, simply interchangeable, made of quartz and glass respectively, so that greater dispersion can, if desired, be attained in the longer wavelength region.

Absorption spectra were measured in purified n-hexane. Concentrations were throughout kept at O. 5 × 10^{-4} M. The compounds used were pure as judged by their melting points.

Absorption spectrum of phenacyl bromide (ω. Bromo acetophenone), ∝-bromo ∝-formyl acetophenone and ∝-Bromo ∝-formyl p-chloro acetophenone have been recorded in the present communication.

ACKNOWLEDGEMENT

The authors' thanks are due to Dr. D. D. Pant for his valuable suggestions.

SUMMARY

Absorption spectra of ∝-Bromo ∝-formyl acetophenone and p-chloro ∝-Bromo ∝-formyl acetophenone have been studied in n-Hexane. The results show that introduction of a formyl radical has a bathochromic effect. In case of p-chloro ∝-formyl ∝-chloro acetophenone there is no absorption band corresponding to phenyl radical. To explain the absence of absorption band due to phenyl radical (i. e. 280 mμ region) quinoid type of contributing structures have been suggested.

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STUDY OF HYDROGEN BONDING IN BINARY LIQUID MIXTURES*

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The formation of hydrogen bond in substances accounts for the abnormal behaviour in their physical properties.[1] To explain the marked decrease in the parachor values of some typically associated liquids from that of theoretical Sidgwic[2] introduced the idea that an increase of covalency of hydrogen results in a decrease in parachor values. Thus the lowering in parachor values in alcohols, diketones, carboxylic acids were all accounted for on the above basis. Later the same reasoning was given by Speakman[3] for elucidating the decrease in parachor value of hydrogen fluoride. Bhagwat and co-workers[4] extended the study of hydrogen-bond by the mixture law as applied to parachor, to molecular associations. They confined studies to a few ethers and alcohols mixtures, and to mostly of the type whose components were differing much in their values of surface tension.

It is the object of the present work to carry out a comprehensive study in more accurate manner, by choosing all type of inter-molecular mixtures whose components may or may not differ much in their values of surface tension.

EXPERIMENTAL

The parachor and density measurements of the mixtures and their individual components were carried out in a thermostat maintained at a temperature of 30° C ± ·05° C. For parachor determination, the surface tension was obtained by Jaegar's bubble pressure method[5] as improved upon by Sudgen[6], by introducing two tubes instead of one in the bubbler.

The ketones and alcohols mixtures were chosen for the purpose and the results are given in figures 1 to 6. Some observations were also taken using alcohol and ether mixtures. For brevity sake only a few characteristic graphs have been given and all the tables and readings have been omitted, except the final results which have been included in the discussion part,

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* M. Sc. thesis submitted to the Agra University, 1955.

[1] L. PAULING "The nature of the chemical Bond" Ed. 1950, page 286.

[2] S. GLASSTONE, "Recent Advances in Physical Chemistry." Ed. 1938, page 123-124.

[3] SPEAKMEN, "Nature," 1932, page 129-244.

[4] TRIVEDI, KAVEESHWAR and BHAGWAT, "Agra University Res. Journal, July 1953, Vol. II, part II.

[5] JAEGAR, Z. Anrg. Chemic., 1911, 101, page 1.

[6] SUDGEN, J. C. S., 1922, 121, page 684 and 1924 27, page 125.

DISCUSSION

Hammic and Andrew[7] pointed out that the mixture law as applied to parachor is only applicable in case of binary liquid mixtures, when their surface tensions do not differ from each other by more than seven units. If they do, the parachor value of solute is found less and increases in a linear manner with the molar fraction of the solute; but however the extrapolated value for one mole fraction gives a correct value.

On applying the mixture law of parachor to binary liquid mixtures, the surface tension values of whose components differ by more than seven units, and are known to be molecularly associated, the calculated parachor values of the solute are not found to be a linear function of Molar fraction. However the parachor values of mixture are found to be a linear function of the molar fraction of the solute. Now using the mixture law equation

$$Pm=(1-x)\ Pp+xPx$$

and on slightly rearranging it,

$$Pm=Pp+x\ (Px-Pp)$$

where Pm, Pp, Px are the parachor values of mixture, solvent and solute respectively and x is the molar fraction of the solute.

The parachors of the individual components of any binary liquid mixture, would be a fixed constant quantity and so is the differential value of the two. Therefore it can be seen from the above equation that Pm, the parachor of mixture will vary linearly with x, the molar fraction of the solute.

Pm becomes equal to Px i.e. if the plot between Pm and x is extrapolated to one molar fraction, then the value of parachor of mixture so obtained will be the true parachor value of that of solute. It would also convincingly prove, that the deviation in the parachor value so obtained from that of the pure solute, is not simply due to the differences in the surface tensions of the two components, but due to the molecular association between them. So in all the cases studied the extrapolation device was adopted, instead of taking the mean of the parachor values obtained by applying mixture law as was done by the earlier workers[4].

Binary mixtures whose components differ by more than 7 dynes/cm. in their surface tensions.

The solutions of acetone or ethyl methyl ketone in benzyl alcohol, diethyl ether in N-Amyl alcohol and of acetonyl acetone or of acetophenone in homologous alcohols fall under this category. In the former case the surface tension of the solvent exceeds that of solute by more than 7 dynes/cm. whereas in the latter case it is just the reverse.

(a) *Acetonyl acetone or Acetophenone in various Homologous Alcohols:—*

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[7] S. GLASSTONE, "Recent Advances in Physical Chemistry," Ed. 1938, page 108.

On extrapolating the plots between the molar fraction and parachor of mixtures of acetonyl acetone in homologous alcohols (from methyl to octyl alcohol leaving heptyl) to one molar fraction; it can be seen from figures 2 & 5 that all of them converge in the neighbourhood of a point which corresponds to the apparent parachor value of the solute in the mixture. In the case of acetonyl acetone all the lines meet in the neighbourhood of 281, whereas in the

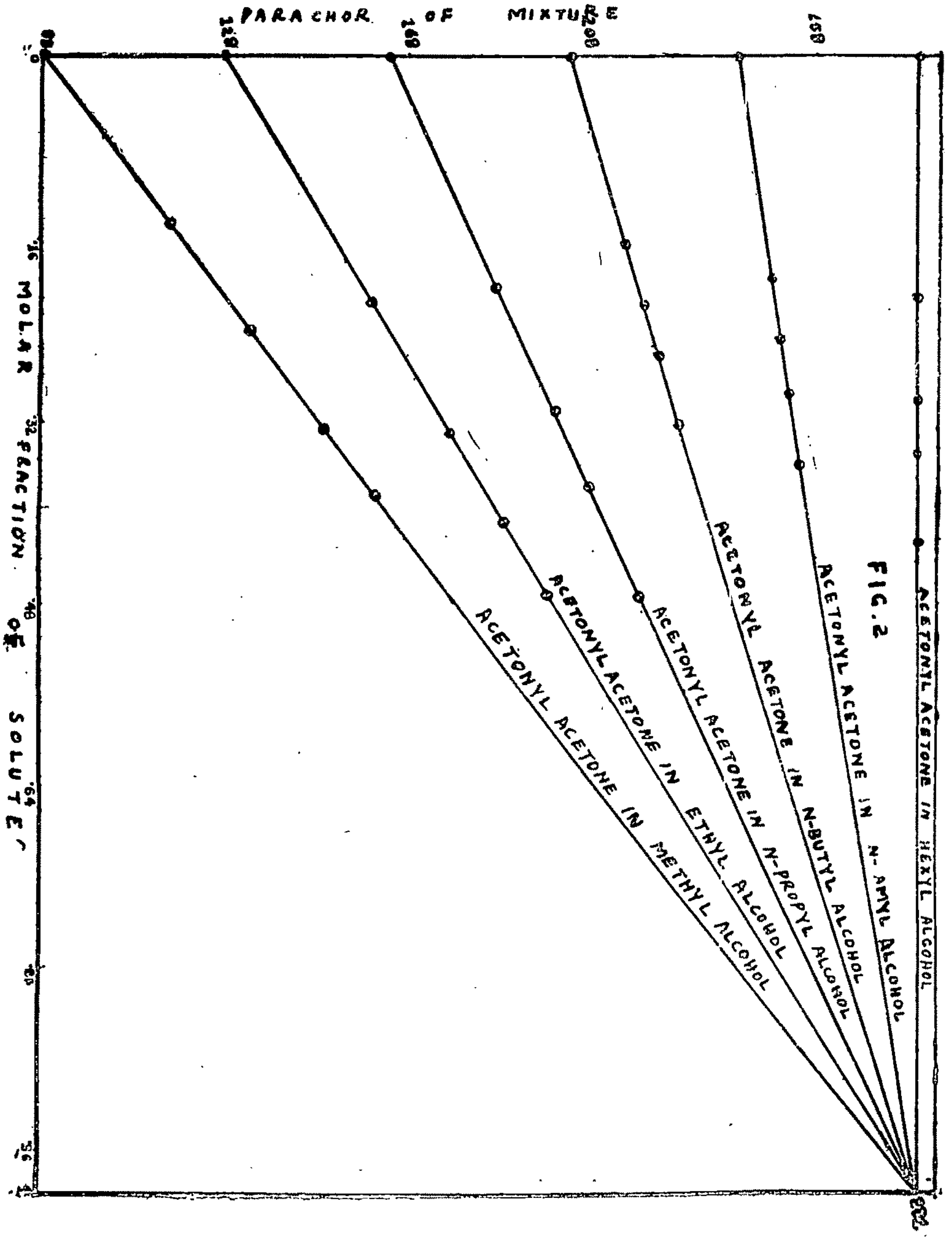


FIG. 2

case of acetophenone (a similar type of graph is obtained) they converge to 285 (fig. 4). The experimental values for parachor of pure acetonyl acetone and acetophenone alone comes out to be 286 and 292 respectively. So the lowering in parachor due to hydrogen bonding between acetonyl acetone and homologous alcohols is by 5 units, whereas in the case of acetophenone and homologous alcohols it is 7 units. On calculating the parachor value of the

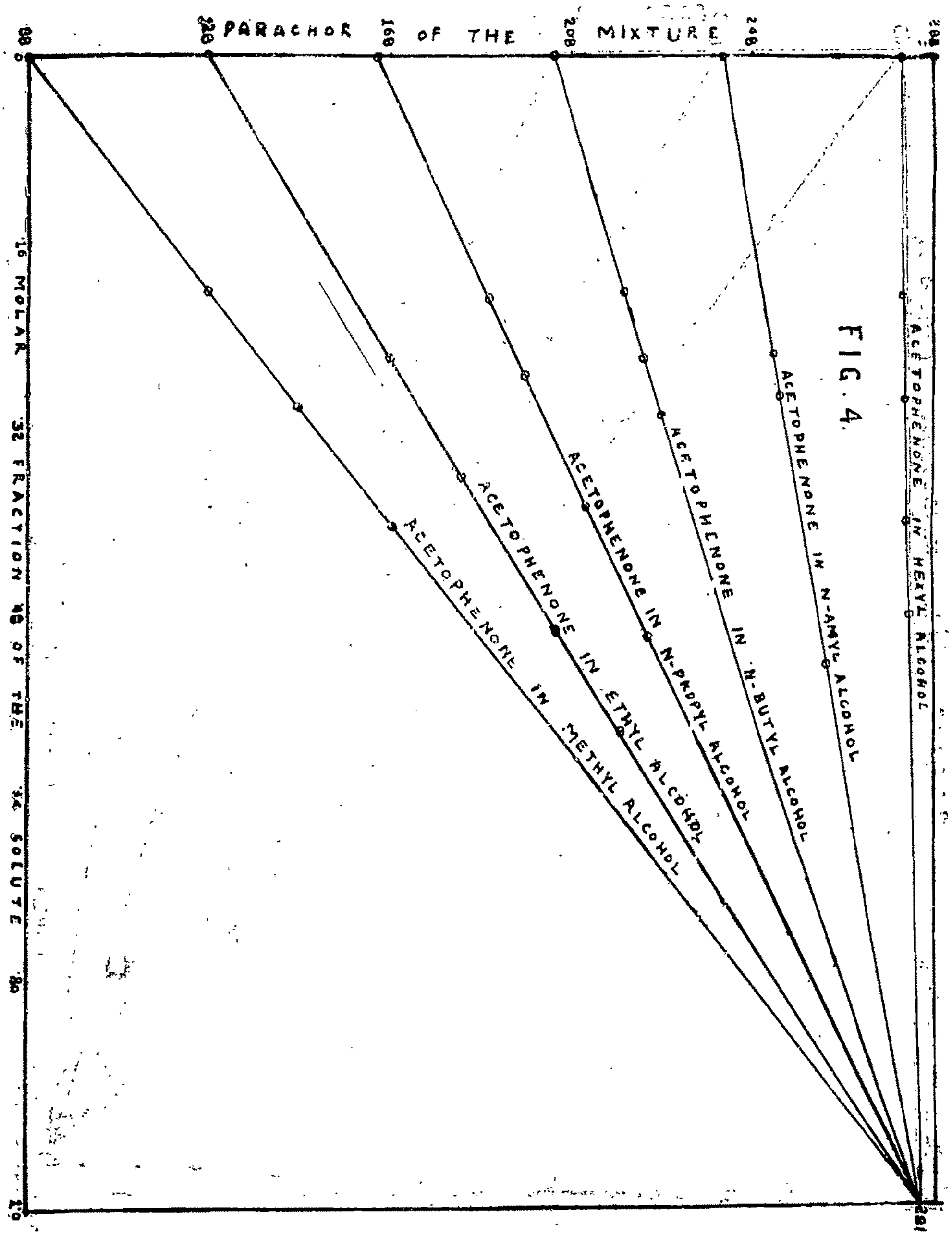


FIG. 4.

solutes by applying mixture law, the decrease in parachor value for acetonyl acetone ranges from 6 units to 9 units; whereas in the case of acetophenone it varies from 10 units to 16 units in all the homologous alcohols.

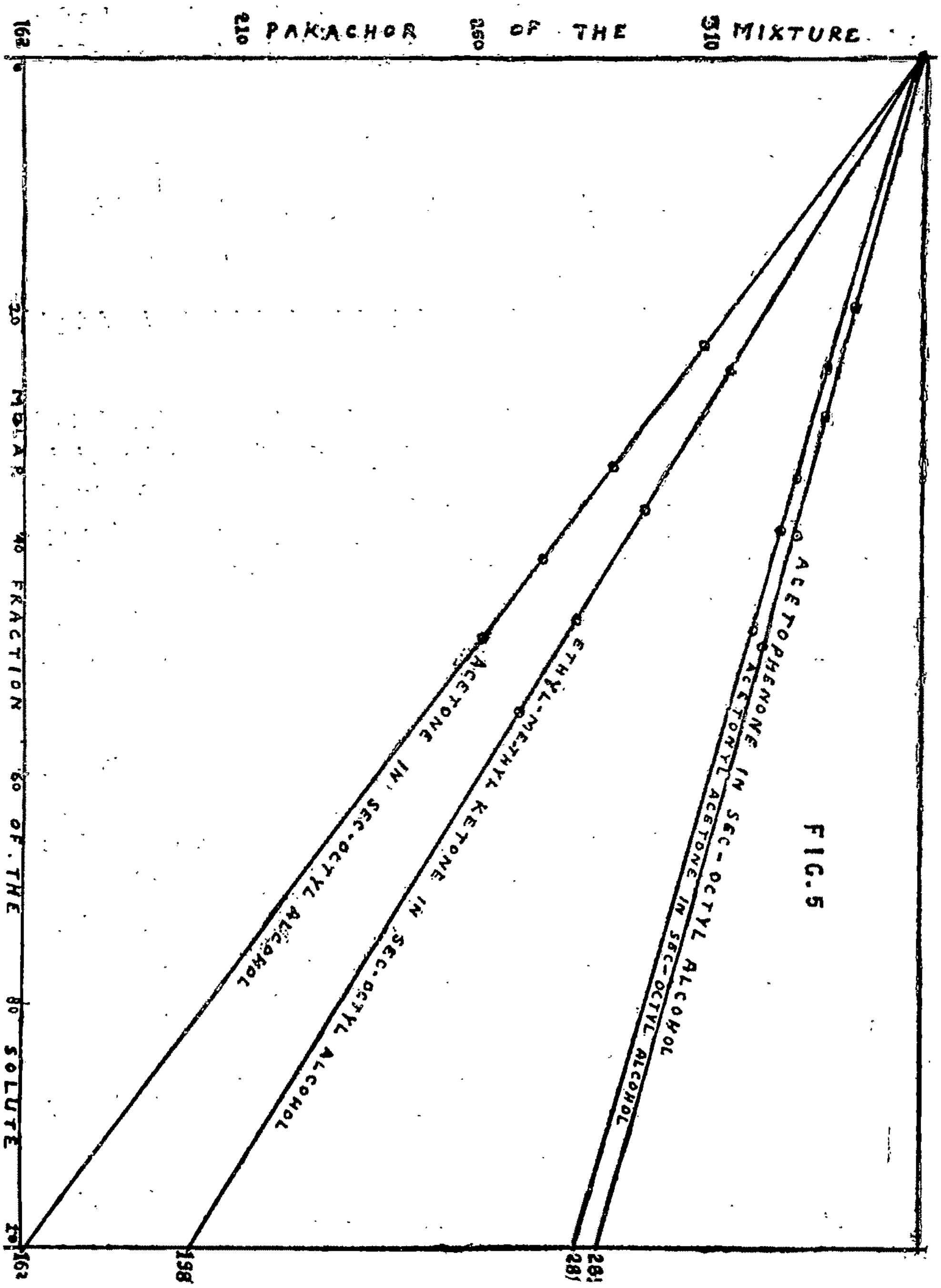
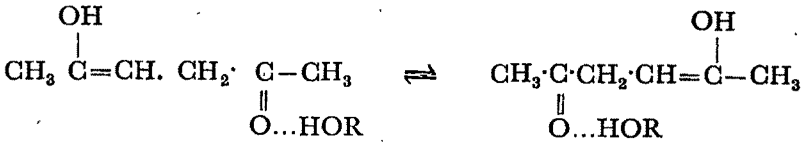


FIG. 5

The larger decrease in parachor in the case of acetophenone may probably be due to the fact that keto-group in acetophenone is more electronegative in character as compared to that of acetonyl acetone. As the acetonyl acetone contains two keto groups, the following structures are possible for intermolecular association, taking into account the possibility of enolisation of one of the keto-groups.



$$\mathrm{CH_3\,\overset{OH}{\overset{|}{C}}{=}CH.\ CH_2\cdot\ \underset{O\ldots HOR}{\underset{\|}{C}}-CH_3\ \rightleftharpoons\ CH_3\cdot\underset{O\ldots HOR}{\underset{\|}{C}}\cdot CH_2\cdot CH{=}\overset{OH}{\overset{|}{C}}-CH_3}$$

(*b*) *Acetone or Ethyl Methyl ketone in Benzyl Alcohol and Diethyl ether in N-Amyl Alcohol.*

In this series the surface tension of solutes is much lower than that of the solvent. In such case also the lowering in parachor is observed and it is 9,8.5 and 9.5 units respectively for diethyl ether, acetone and ethyl methyl ketone as shown in fig. 6. Hence for the study of hydrogen bonding by parachor technique it is immaterial, whether the surface tension of the solute is greater than that of the solvent or vice versa.

(ii) *When the surface tensions of the components of a Binary mixture do not differ by more than 7 dynes/cm.*

The mixtures of acetone or ethyl methyl ketone in homologous alcohols and of anisol, acetonyl acetone or acetophenone in benzyl alcohol belong to this type. In case of acetone or ethyl methyl ketone solutions in homologous alcohols, all the extrapolated lines between parachor of mixture and molar fraction converge in the neighbourhood of 162 and 199 respectively. In both the cases similar graphs are obtained. The results corresponding to acetone and ethyl methyl ketone are given in figs. 1, 3 & 5. The experimental parachor values of the pure acetone or ethyl methyl ketone individually are 161.5 and 198.5 respectively. On comparing the two respective values in the above case, no lowering is observed in the parachor values, showing thereby the limitations of parachor technique for the study of hydrogen bonding in all types of the mixtures. The study of mixtures of anisol or acetonyl acetone or acetophenone in benzyl alcohol also support the above conclusions (vide fig. 6).

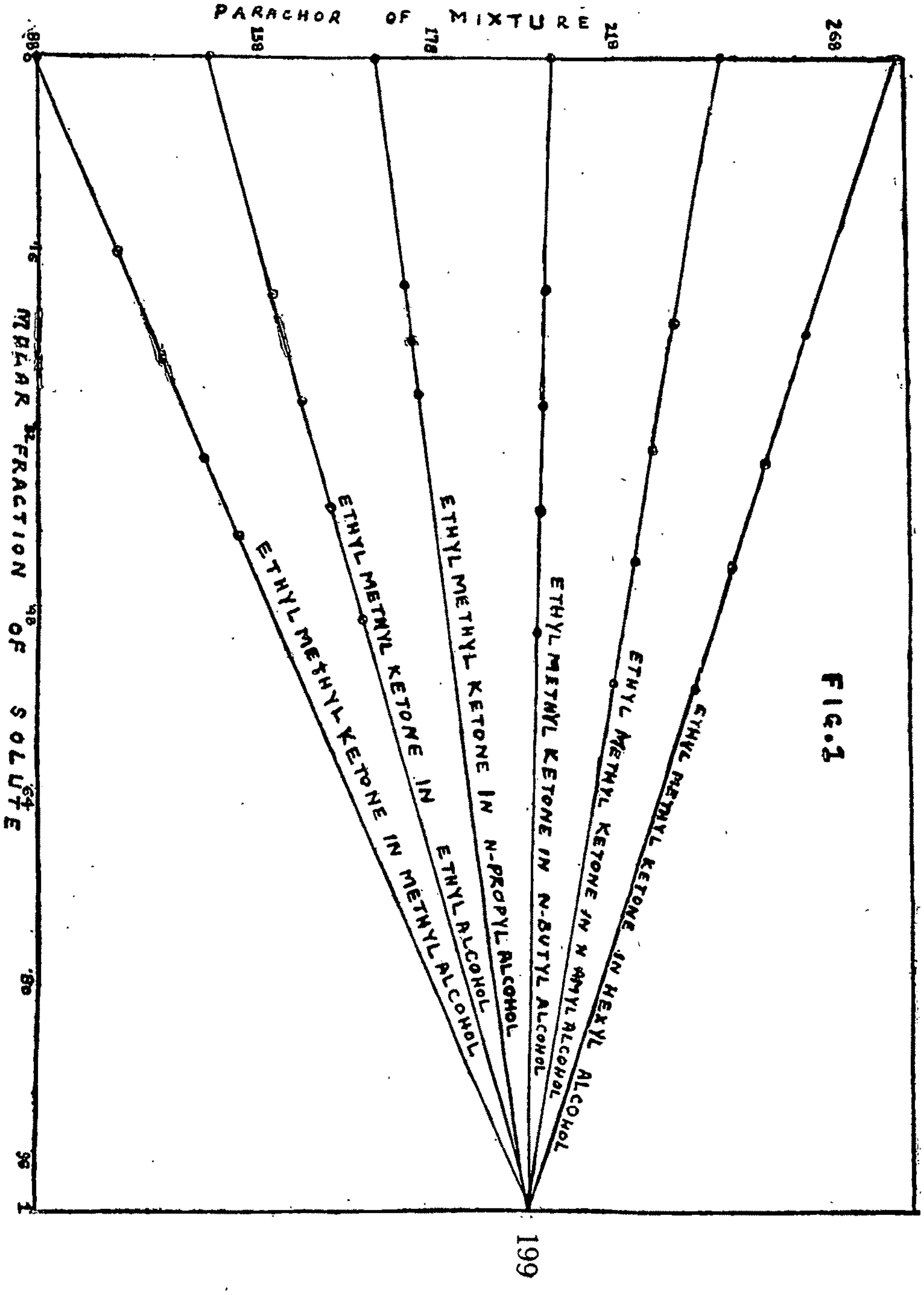

PARACHOR OF MIXTURE
88
158
178
218
268
199
MOLAR FRACTION OF SOLUTE
0
.16
.32
.48
.64
.80
.96
1
ETHYL METHYL KETONE IN METHYL ALCOHOL
ETHYL METHYL KETONE IN ETHYL ALCOHOL
ETHYL METHYL KETONE IN N-PROPYL ALCOHOL
ETHYL METHYL KETONE IN N-BUTYL ALCOHOL
ETHYL METHYL KETONE IN N AMYL ALCOHOL
ETHYL METHYL KETONE IN HEXYL ALCOHOL

FIG. 1

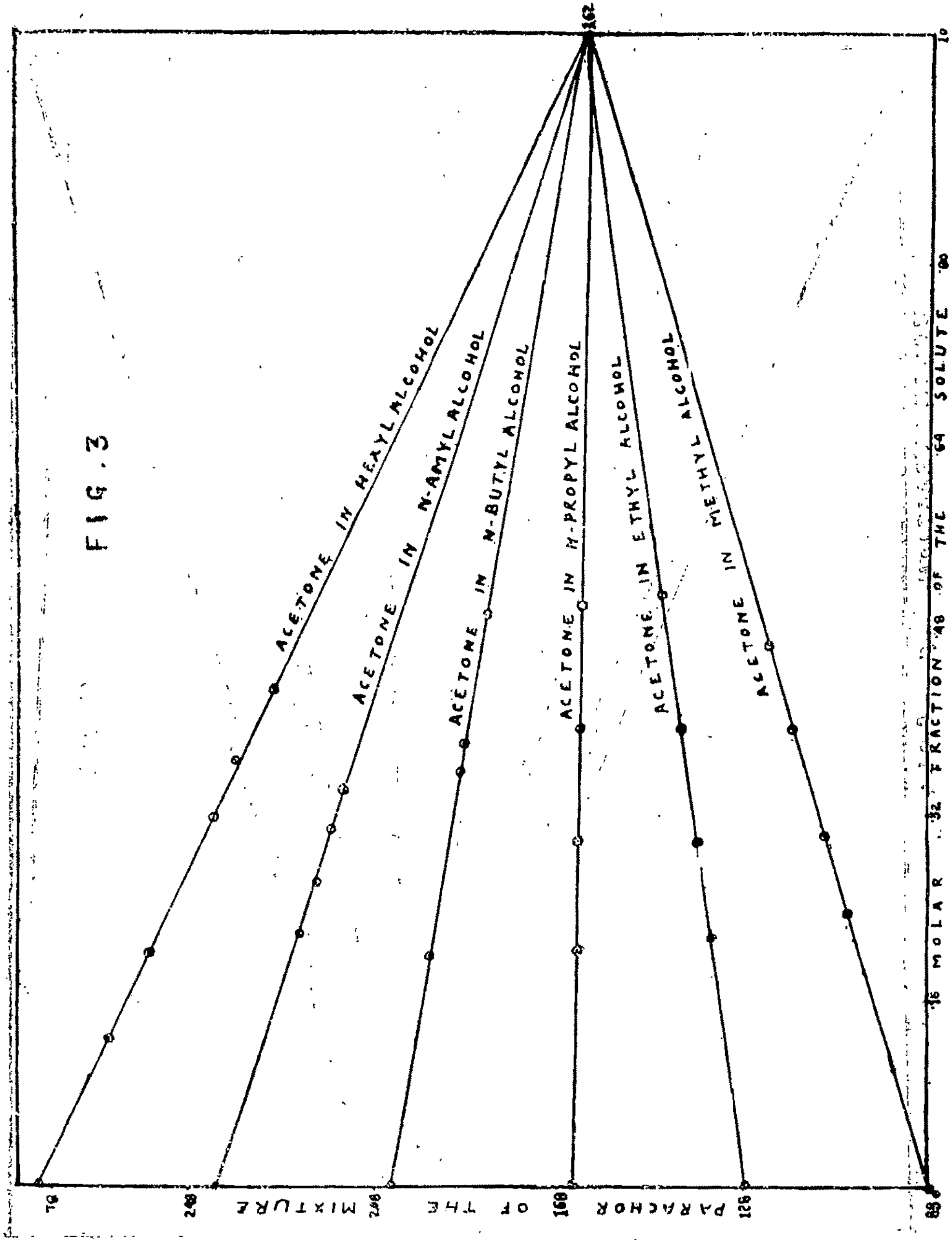

ACETONE IN HEXYL ALCOHOL
ACETONE IN N-AMYL ALCOHOL
ACETONE IN N-BUTYL ALCOHOL
ACETONE IN N-PROPYL ALCOHOL
ACETONE IN ETHYL ALCOHOL
ACETONE IN METHYL ALCOHOL
MOLAR FRACTION OF THE SOLUTE
.16
.32
.48
.64
.80
1.0
PARACHOR OF THE MIXTURE
88
126
168
206
248
162

FIG. 3

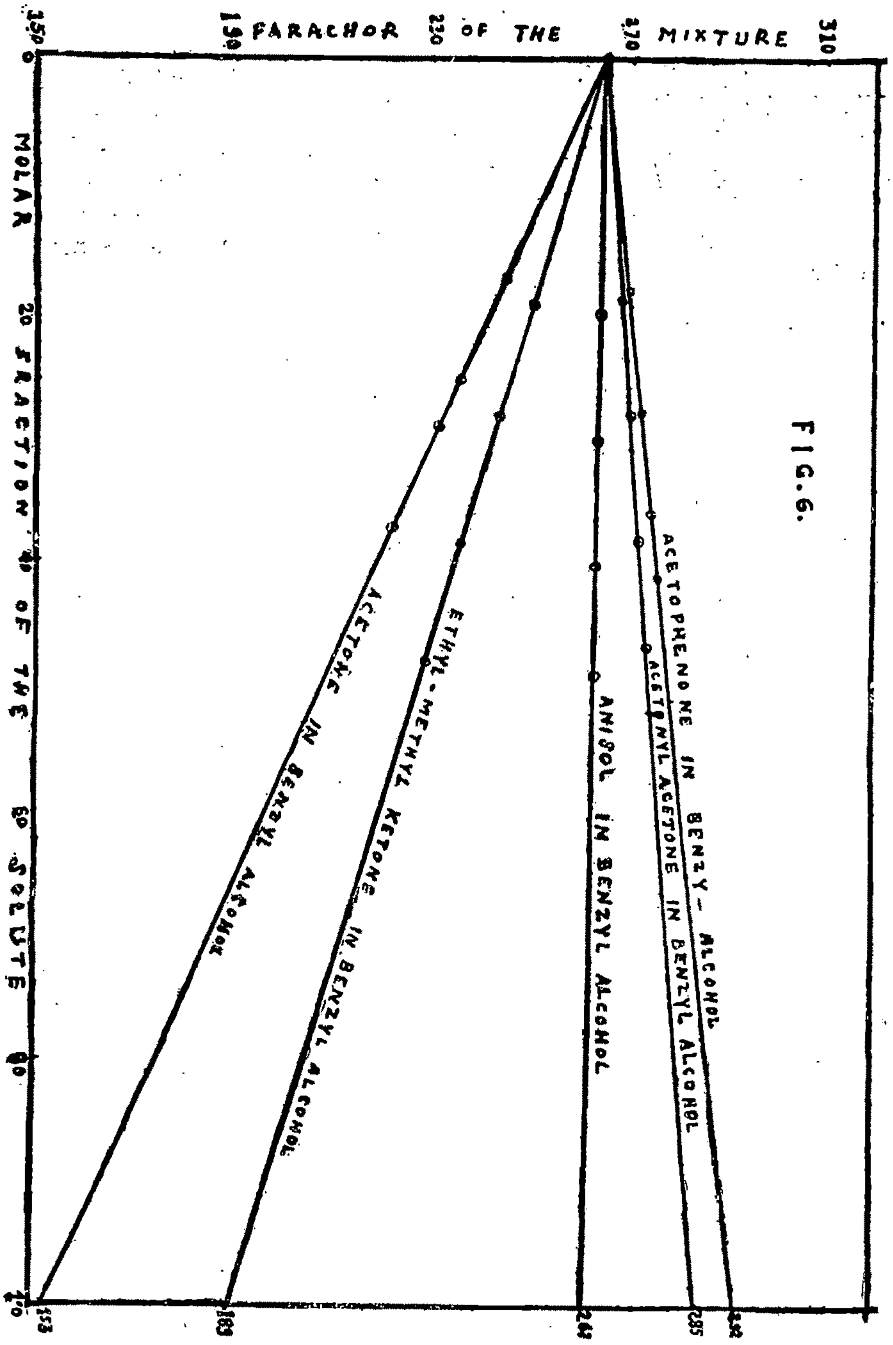


FIG. 6.

The authors wish to thank Prof. H. L. Rohatgi, Principal, D. A. V. College, Kanpur, for giving necessary facilities to work, and Shri K. P. Bhatnagar, Vice-Chancellor, Agra University for his kind interest in the work.

SUMMARY

An extrapolation technique has been adopted for the study of hydrogen bonding in binary liquid mixtures, by the mixture law of parachor. From the results obtained, it is shown that so long as there is a difference of more than 7 dynes /cm between the surface tensions of the two components of a binary mixure, the lowering in the parachor value is observed, due presumably to the formation of hydrogen bonding between the associated molecules.

SMOOTHNESS OF FADING PATTERNS OF SHORT WAVE RADIO SIGNALS NEAR MAXIMUM USABLE FREQUENCY

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D. Jain College, Baraut (Meerut).

INTRODUCTION

Fading of radio signals received at long distance from the transmitter is well known. Out of the several causes of such fading, interference between the magneto-ionic components is very prominent. Such fading patterns on short wave radio signals have been studied in detail and it has been observed that on several occasions they are found to be considerably smoother than the patterns usually obtained. The purpose of present communication is to show the cause of such smoothness of fading patterns and its relation with the ionospheric conditions. The general absence of smoothness is due to the fact that there are intensity variations of the different interfering waves or of a single wave. This intensity variation of a single down coming radio wave has been studied by Ratcliffe(1)and others (2,3)and they consider a single wave returned from the ionosphere as equivalent to a cone of rays returned to the receiver from a diffuse scattering region in the ionosphere. As a consequence of this fading of a single wave in a random manner has been explained.

EXPERIMENTAL ARRANGEMENT

Fading patterns studied during the course of present investigations were recorded by an automatic pen recorder constructed for the purpose. The experimental arrangement in brief consists of the following parts:—

(a) Superheterodyne receiver in which the automatic volume control system was made inoperative.

(b) Direct-coupled amplifier for pen recorder.

(c) An automatic recording arrangement with a sensitive and strong moving coil galvanometer of low resistance.

D. C. voltage developed across the load resistance in the second detector stage of the superheterodyne set is applied between the grid and the cathode of the first valve of the amplifier which is a voltage amplifier. The plate of the first valve is directly connected to the grid of the second valve and by putting a suitable resistance between the grid and the cathode of this valve and by maintaining its cathode at a proper high voltage a negative bias is made applicable to its grid. The recording galvanometer is connected in the plate circuit of the second valve which is a power amplifier. As soon as a station is tuned a negative potential is applied to the grid of the first valve and thus its plate current is reduced. Due to the reduction of the current through the resistance between the grid and the cathode of the second valve the negative bias on it decreases and a current depending upon the strength of the signal flows through the recording galvanometer as previous adjustments are made such that when there is no signal, the plate current passing through the recording galvanometer is zero.

A specially made pen is suspended vertically at the end of the pointer of the galvanometer which just touches the recording paper. Due to fading there is variation in the D.C. voltage developed across the load resistance in the second detector stage which in turn gives a corresponding variation in the current flowing through the galvanometer. The pen attached to galvanometer thus moves horizontally. The paper is moved vertically at a constant speed by a motor and gear arrangement and thus the records of fading are obtained. A circuit diagram of the recorder is shown in fig. 1 (a).

OBSERVATION AND DISCUSSION OF RESULTS

In order to collect the information regarding the smoothness of the fading patterns and its variation as the frequency of transmission approaches the maximum usable frequency (m.u.f.) following three kinds of observations were recorded:—

1. Observation of fading of radio signals on different frequencies from any transmitting station at nearly the same time.
2. Observations of fading of radio signals from different transmitting stations at different distances from the receiving station on the same wave band at nearly the same time.
3. Continuous observations of fading of radio signals on any frequency when the ionic density was increasing or decreasing.

A brief summary of one set of observations of the first type is given in table I.

Table I

Transmitting station Delhi Receiving station Banaras

Serial number	Date	Time of observation in I. S. T.	Wave band in metres	Degree of smoothness
1. (Fig. 1)	3.7.50	1340	19	slightly smooth
2. ,,		,,	16	smooth
3. ,,		,,	13	perfectly smooth

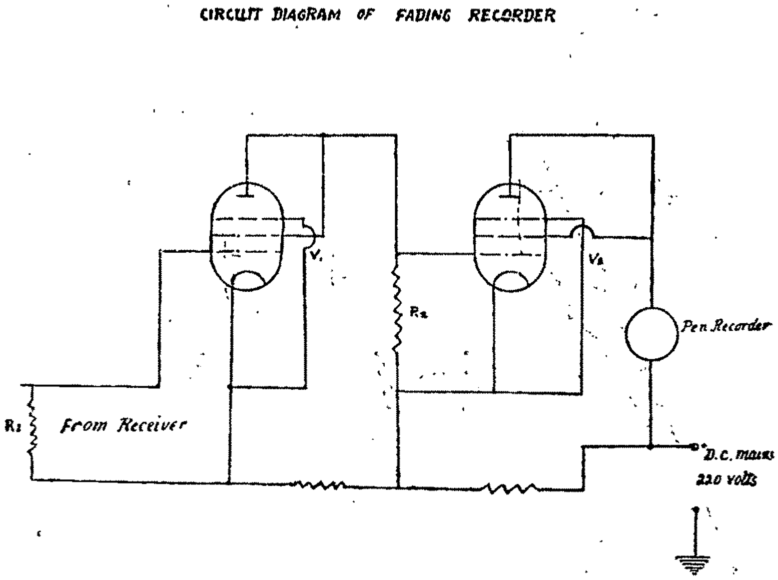
CIRCUIT DIAGRAM OF FADING RECORDER
V1
V2
R2
Pen Recorder
R1
From Receiver
D.C. mains
220 volts

Fig. 1 (a)

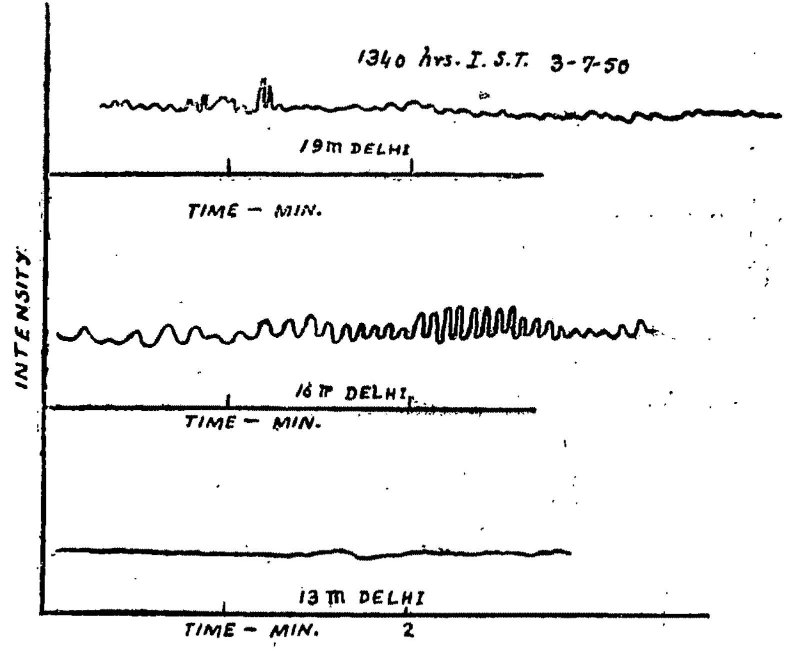
1340 hrs. I.S.T. 3-7-50
19m DELHI
TIME — MIN.
INTENSITY
16 m DELHI
TIME — MIN.
13 m DELHI
TIME — MIN.
2

Fig. 1.

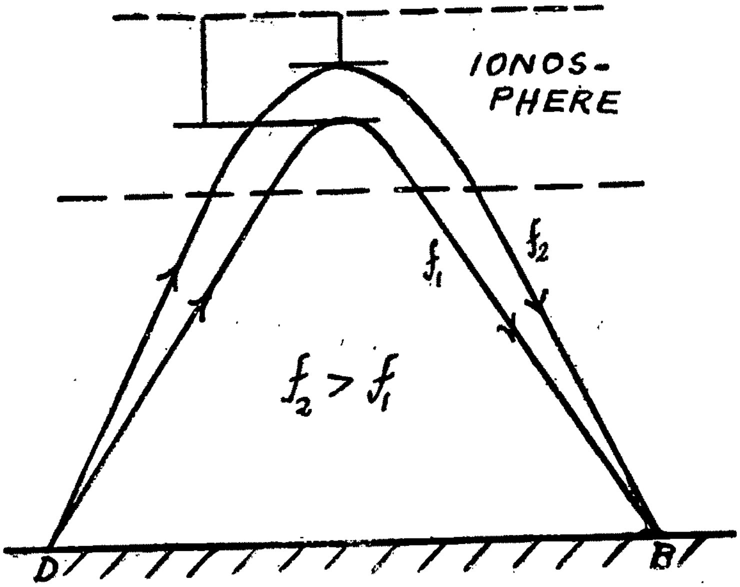
IONOS-
PHERE
f1
f2
f2 > f1
D
B

Fig. 2.

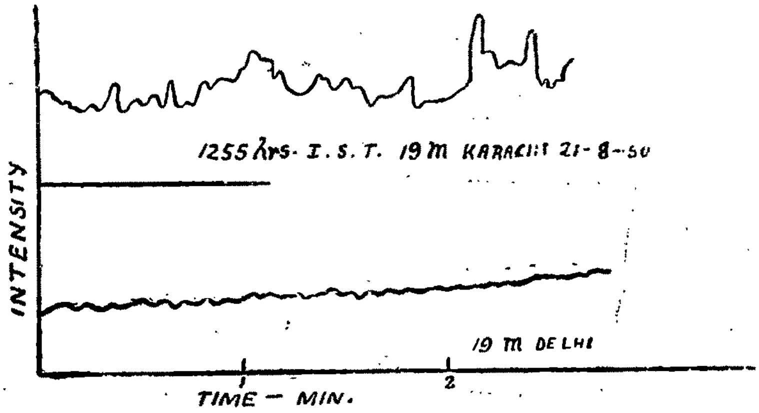
INTENSITY
1255 hrs. I.S.T. 19 m KARACHI 21-8-50
19 m DELHI
1
2
TIME — MIN.

Fig. 3 (a)

For illustration the above fading patterns are shown in Fig. 1. It will be observed from the above figure that as the wave length is decreased or the frequency is increased the fading pattern becomes smoother. This is due to the fact that the vertical gradient of the electronic density in the ionosphere increases upwards due to the parabolic distribution of the electronic density in the ionosphere. As the frequency of transmission increases, the point of reflection in the ionosphere rises higher and higher as shown in fig. 2. Now a single wave reflected from a region of higher electronic density gradient may be regarded as equivalent to a cone of rays returned to the receiver from a diffuse smaller scattering region in the ionosphere than that when it is reflected from a lower level. The degree of randomness may, however, depend on the size of the scattering region and so the rays reflected from the higher region of the layer will show less variations in their intensity.

Observations of the second type have been included in Table II and the corresponding fading patterns are givenin fig. 3.

Table I

19 metre—band.

Serial Number	Date	Time of observation in I. S. T.	Transmitting Station	Degree of smoothness.
1. Fig. 3 (a)	21/8/50	1255	Karachi	Not smooth
,,	,,	,,	Delhi	Smooth
2. Fig. 3. (b)	25/8/50	1300	Karachi	Slightly smooth
,,	,,	,,	Delhi	Perfectly ,,

It will be observed from Table II that greater the distance between the transmitter and receiver less smooth is the fading pattern. This is due to the fact that the m.u.f. factor increases with the distance between the transmitter and the receiver, and consequently, the increase of distance is equivalent to shifting the frequency of transmission away from the m.u.f., which in turn will mean the reflection from lower level, as shown in fig. 4, and consequently increase in the randomness.

The third type of observations relate to the continuous recording of fading on any particular frequency, when the frequency of transmission is approaching or receding from m.u.f. due to change in ionospheric conditions (4, 5, 6). It may be mentioned, however, that the change in electronic density is not the only factor which determines the variations of maximum usable frequency. Very often change in the thickness of the layer over balances the effect of the change in the electronic density. For the study of the smoothness under these conditions, we have, therefore considered the variation of smoothness of the fading patterns with the approach of the frequency of transmission near the m.u.f. due to the aggregate change in ionospheric conditions. In order to be sure of the change of ionospheric conditions, the study was confined only to the following types of fading patterns under this category.

(a) Disappearance patterns of short wave radio-signals obtained in the after-noon and evening hours, due to decreasing electronic density.

(b) Appearance of short wave radio signals in the morning hours when the ionic density is increasing.

(c) Disappearance of short-wave radio signals due to the thermal expansion of the layer, in the morning and noon hours.

It may be mentioned that in all the above types of observations one can easily find whether the frequency of transmission is approaching the m.u.f. or is moving away from it. Table III gives the summary of a few such observations.

Table III

Serial Number	Date	Time of observation in I.S.T.	Wave band & station	Degree of smoothness	Remarks.
1. Fig. 5.	31/10/50	1842	16m. Delhi	Slightly smooth	Frequency of transmission approaching m.u.f.
,,	,,	1845	,,	Smooth	
,,	,,	1902	,,	,,	
2. Fig. 6.	23/5/50	0637	25 m. Delhi	Smooth	Frequency of transmission moving away from m.u.f.
,,	,,	0653	,,	Not smooth	
3. Fig. 7.	12/10/50	0752	19m.Delhi	Not smooth	Frequency of transmission approaching m.u.f.
,,	,,	0804	,,	slightly smooth	
,,	,,	0812	,,	Smooth	

The first set of observations in above table and the corresponding fading patterns given in fig. 5 relate to the dis-appearence of short-wave radio-signals with the approach of evening and night hours when the electronic den-

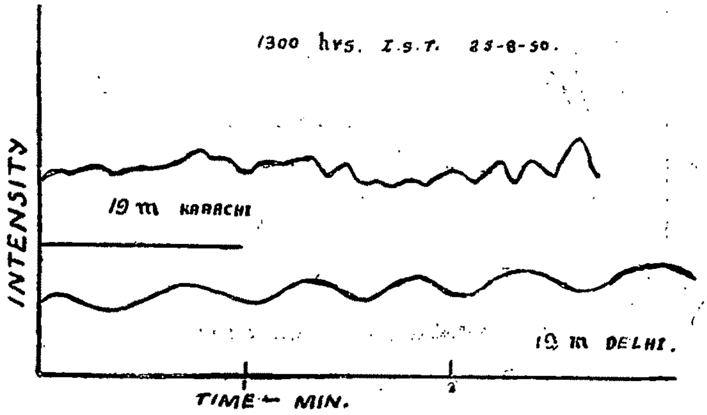

Fig. 3 (b)

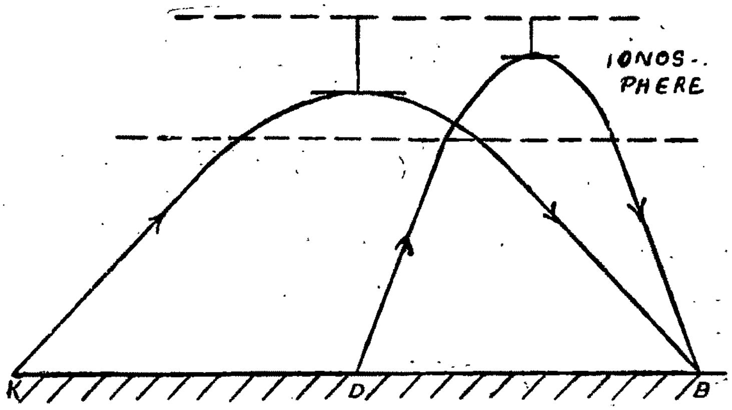

Fig. 4.

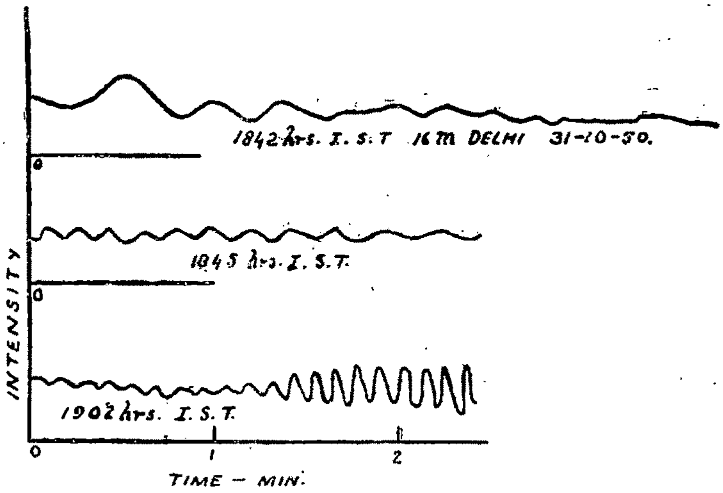

Fig. 5.

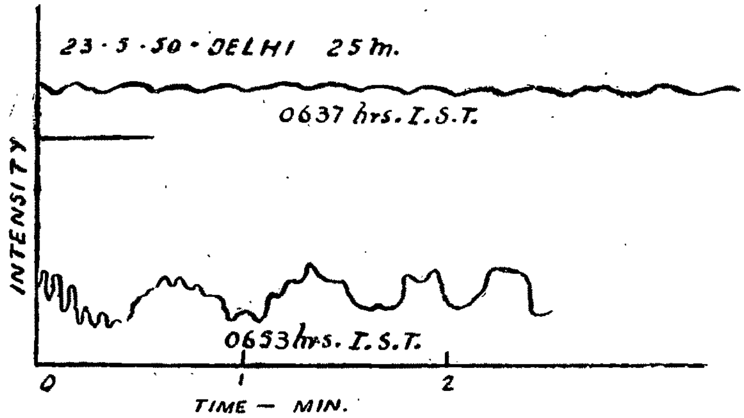
23·5·50·DELHI 25 m.
0637 hrs. I.S.T.
0653 hrs. I.S.T.
INTENSITY
0
1
2
TIME — MIN.

Fig. 6.

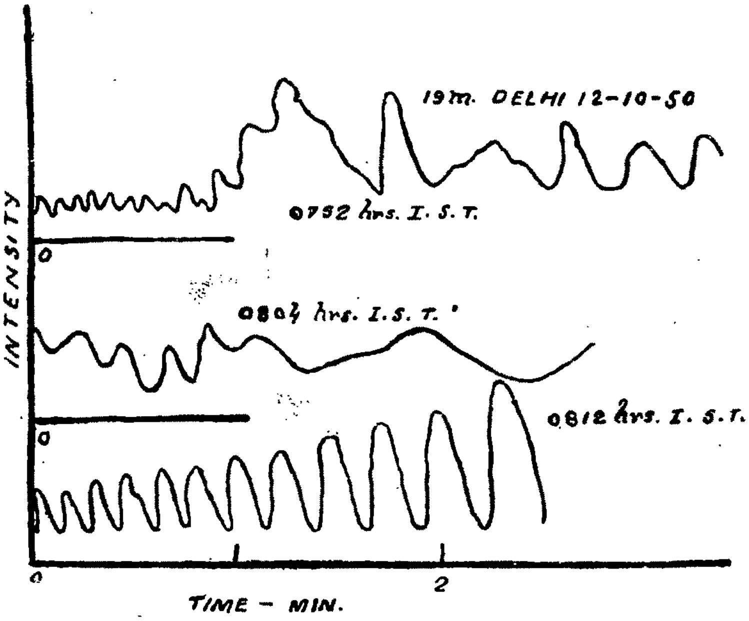
19 m. DELHI 12-10-50
0752 hrs. I.S.T.
0802½ hrs. I.S.T.
0812 hrs. I.S.T.
INTENSITY
0
0
0
2
TIME — MIN.

Fig. 7.

sity falls in the F_2 region of the iono-sphere. Second type cf observation in this category given in the same table and the corresponding fading patterns given in the fig. 6 relate to the usual appearance of short wave radio signals in the morning hours due to increasing electronic density. In this case the frequency of transmission is receding away from the m.u.f. and as such, with the increase of time decrease in smoothness is obtained. The third and the last set of observations in Table III and the corresponding fading patterns given in the fig. 7 represent the disappearance of radio-signals in the morning and noon hours due to the thermal expansion of ionospheric layers as reported and explained by Banerjee and his collaborators (7).

Thus all the above types of observations show that the smoothness of the fading patterns increases as the frequency of transmission approaches the m.u.f. This as explained above, is due to reflection from regions of higher and higher gradient of electronic density as the frequency of transmission is increased. The above conclusion is also corroborated by the pulse observations from Delhi.

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SOME ASPECTS OF THE BIOLOGY OF *BAGRADA PICTA* FABR*

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INTRODUCTION

Bagrada picta is a pest of cruciferae generally throughout India, occurring in very large numbers in some years. In Uttar Pradesh it attacks cauliflower, of raddish and cabbage. Early in the winter mating adults and different stages nymphs are seen chestering on the leaves and cause severe damage by sucking sap from the plant. Lefroy (1906 and 1919) has given a short description of the feeding habit of the pest. Fletcher (1914 and 1919) has described the pest and studied its distribution in India. Hoffmann (1934) has published some notes on the bionomics of some Oriental pentatomidae. Ayyar (1940) mentioned *Bagrada* as a pest. Similarly Samual (1942, 1954) published a comprehensive account of the pest and its egg parasite. Lall (1946) described the brief life-history of the pest along with some control measures. The biology of *Piezodorus* (a pentatomid bug) is studied in good details by Joseph (1953).

These scattered accounts do not reveal the detailed biology of the insect. In the present paper the author has tried to study the detailed biology of the pest. The conclusions are based upon quite a large number of observations. The biology is studied under laboratory conditions and checked under field conditions. Striking differences in the biology under the two conditions are noted down.

TECHNIQUE

The insects were collected in the month of October and November, 1956 from the cabbage fields near Agra.

In the laboratory they were reared in glass tubes 4″ × 1.″ Single pair was kept in a tube covered by muslin in which young cabbage leaves were provided as food. The average maximum and minimum temperatures were 79° F and 68.5° F respectively and humidity recorded was 52% and 73%. Withered leaves were changed daily at 7 a.m. and again at 4 p.m. At the same time the muslin, tubes and the leaves were carefully examined for eggs and moults. Eggs laid on the leaves were not separated and if they were found on the muslin, they were collected along with muslin and placed in covered petri-dishes.

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Under field conditions the young potted cabbage plants were covered by a cylinder of wire gauze open at the base and closed above and a pair of insects was introduced on each plant. Every day they were observed after an interval of three hours between 7 a.m. to 7 p.m. for moults, eggs and feeding etc. After laying one batch of eggs the insects were transferred to other potted plant or the leaf containing the laid eggs was separated according to convenience. The average maximum and minimum temperatures and humidity recorded in the field were 82.5° F & 64° F, and 60% R.H. and 73% R.H. For recording the measurements etc., the insects were first killed in AEther and then the measurements were taken. Later they were preserved in 80% Alcohol.

For observing the differences in the 2 sexes of the 5th stage nymphs, they were separated according to the sizes and reared separately. Samples of specimens from both the groups (smaller and larger) were treated with KOH and permanent slides of the genitalia were prepared.

LIFE HISTORY

(a) **Copulation**:—(Fig. 10).

The female bugs were bigger than the males. It has been observed that before copulation the male touched the female antenna with its own and then mounted on the back of the female and started copulation. After 7-10 minutes the male got down and took up tail to tail position with the female. During copulation flight was not very successful and generally they stayed motionless or hide themselves on the under surface of the leaves. The period of copulation was very variable extending from ten minutes to a week. If they copulated for longer period the female died but the male did not leave it and ultimately both of them died.

(b) **Oviposition**:—

If oviposition was prolonged, the female died after laying few eggs or without it. Sometimes aggregation of individuals enhances the rate of mortality (out of five pairs kept together in the laboratory, three females died). Usually the oviposition occurred at night. If male and female were kept together the female separated the male only at the time of egg-laying. Female generally died after laying the last batch of eggs. In the laboratory the eggs were laid in six batches. Generally stray eggs were laid singly; two together were less common and in most rare cases as many as six eggs were seen lying close together. Usually the eggs were seen sticking to the midvein, margin or to the general surface but always on the undersurface of the leaves. Table I shows the laying of eggs under laboratory conditions:—

Table I

No. of eggs laid.

No. of insects.	1st day	2nd day	3rd day	4th day	5th day	6th day	Total no. of eggs.
1.	20	12	11	10	3	2	58
2.	3	13	30	34	26	24	130
3.	10	13	21	23	19	10	96
4.	12	17	23	29	9	2	92
5.	7	12	23	31	19	11	103
6.	13	21	27	19	17	8	105
7.	11	17	23	13	7	4	75
8.	5	13	20	27	18	13	96
9.	2	8	23	28	17	12	90
10.	13	23	31	19	11	9	106
11.	7	12	21	29	17	10	96
12.	2	9	13	23	17	9	73
13.	3	7	18	29	13	9	79
14.	1	5	8	17	8	2	41

Hence the number of eggs laid being 88 eggs per female and 12 eggs per day (average of 14 insects).

Under the field conditions the eggs were again laid for six days. Here also the eggs were usually laid singly. Table II shows the laying of eggs under field conditions:—

Table II

Number of eggs laid

No. of insects.	1st day	2nd day	3rd day	4th day	5th day	6th day	Total no. of eggs.
1.	13	21	34	27	11	2	108
2.	2	13	27	31	19	11	103
3.	13	27	33	29	18	9	129
4.	3	11	19	31	26	18	108
5.	9	18	31	29	19	13	119
6.	17	19	28	33	15	9	121
7.	5	18	28	31	27	19	128
8.	8	23	33	27	18	17	126
9.	13	19	29	32	17	9	119
10.	7	15	29	27	18	12	108

Therefore the eggs laid per female were 116 eggs and about 16 eggs per day (average of 10 insects).

(c) **The eggs:**—(Fig. 1, 2 & 3)

Freshly laid egg was of clear white colour, almost transparent and very delicate. It was cylindrical with both the ends rounded. They were 0.44

mm. to 0.55 mm. long and 0.38 mm. to 0.42 mm. broad (Fig. 1). After sometime they became transluscent and harder. Twenty-four hours after laying, the eggs appeared to be of dirty white colour, and glistening. They were well glued to the surface and slight jurk could not separate them easily. Development of the appendages was marked on the third day and the head capsule was seen beneath the tough cuticle of the egg. The inside of the egg was marked by light pink colour. The attached end of the egg was the posterior end of the embryo and the free end marked the cephalic end. The head capsule showed rapid growth and became darker in colour. During development the shape of the egg underwent temporary changes (Fig. 2).

On the 4th day the egg showed clear and marked development. It was of uniform pink colour, 0.60 mm. to 0.69 mm. long and 0.51 mm. to 0.53 mm. broad. On the 5th day the colour became deep pink and the space about 0.12 mm. at the free end containing the thorax was clearly delimited. On the 6th day the thorax grew in width and the egg became broader anteriorly. Increase in length was also marked and the colour changed to light brown. The constricted thoracic area became deeper in colour.

On the 7th day the eggs under the field conditions were 0.73 mm. long and 0.63 mm. broad. The cephalic end was slightly broader than the hinder end, and the constricted dark coloured area looked like a lid or cap. At this stage the hatching took place (Table III, Fig. 3).

Table III

Hatching of 1st nymph under the field conditions where the upper figures in column 2 indicate the date of laying and lower the number of eggs laid and in column 3 the upper figures indicate the date of hatching and the lower the number of nymphs hatched.

No.	Date of laying	Date of hatching	Hatching period.
1.	14.11.56/29	20.11.56/9	6 days
		21.11.56/11	7 ”
		22.11.56/9	8 ”
2.	16.11.56/35	23.11.56/16	7 ”
		24.11.56/15	8 ”
		No emergence/4	
3.	17.11.56/37	23.11.56/10	6 days
		24.11.56/12	7 ”
		25.11.57/9	8 ”
		No emergence/6	
4.	19.11.56/13	25.11.56/4	6 days
		26.11.56/9	7 ”

Therefore the observations on 104 eggs show that the time taken for hatching was 7 days.

Further development was marked in the eggs reared in the laboratory on the 7th day. The cephalic end which appeared like a cap became broader than the caudal end and deep brown in colour. The dimensions were about 1½ times the fresh egg. The length was on an average 0.83 mm. and the width 0.63 mm. The eggs hatched out after the 9th day (Table IV).

Table IV

Hatching of 1st nymph under the laboratory conditions where the upper figures in column 2 indicate the date of laying and lower the number of eggs laid and in column 3 the upper figures indicate the date of hatching and the lower the number of nymphs hatched.

No.	Date of laying	Date of hatching	Hatching period
1.	6.11.56/43	14.11.56/10	8 days
		15.11.56/18	9 "
		16.11.56/11	10 "
		No emergence/4	
2	10.11.56/18	18.11.56/3	8 days
		19.11.56/10	9 "
		20.11.56/5	10 "
3.	17.11.56/29	25.11.56/8	8 "
		26.11.56/12	9 "
		27.11.56/7	10 "
		No emergence/2	

Hence the observations on 84 eggs show that the time taken to hatch was 9 days.

(d) Hatching

The author noticed no change in the hatching of egg under the two different conditions. All of a sudden the lid like anterior cap was opened with a jurk and half of the body of the nymph was seen outside the egg. The half emerged nymph remained in position for about 15 minutes and after this period it crept out of the egg very slowly having a sticky substance over it. For about half an hour it sat motionless near the empty egg case. Soon after the sticky substance got dry and the nymph started moving, leaving behind the empty egg case.

(i) *The first stage nymph*:—(Fig. 4).

The newly hatched nymphs under the two different conditions were of the same colour and shape. The measurements of various parts of the newly hatched nymph are given in Table V. (Average of 6 nymphs).

Table V

Length of nymph	Width of abdomen	Width of thorax	Distance between compound eyes.	Length of antenna.	Length of rostrum.
0.93 mm.	0.76 mm.	0.66 mm.	0.32 mm.	0.6 mm.	0.51 mm.

The colouration was uniform. The dorsal side was of chocolate colour and the ventral deep pink. Segmentation was not marked by different shades of cuticle as in the adults but only by transverse grooves. During walking the head of the nymphs was clearly visible. The 1st thoracic segment was bent downwards and the rostrum was three segmented, the first segment was the longest and dumbell shaped, the two terminal segments were smaller, equal in size, deeper in colour and somewhat barrel shaped. All the segments had few scattered bristles. The antenna was four segmented. The tarsi were 2 segmented and had two terminal hooks in each leg. On the 1st day the feeding and movements were restricted. It avoided light and remained motionless.

By the second and third day the thorax became deeply coloured. It had easy movements. On the mid-dorsal portion three dark coloured wide patches were seen one after the other parallel to the segments but not extending upto the whole surface. They were on the second, fourth and sixth abdominal segments. First patch was the longest and the third smallest. Rest of the dorsal abdominal area was light coloured.

The first stage nymph was most active on the 4th day. They were found busy in sucking the juice from the leaves. Colouration of the thorax and the patches on the abdomen were very clear and deep brown in colour. After the 4th day it moulted (Table VI).

Table VI

Date of first moult together with the number of nymphs moulted where the upper figure in column 2 indicates the date of hatching and the lower the number of nymphs hatched and the upper figure in column 3 indicates the date of the first moult and the lower the number of nymphs moulted.

No.	Date of hatching	Date of 1st moult	Days taken to moult
1.	23.11.56/17	27.11.56/5	4 days
		28.11.56/8	5 ”
		29.11.56/2	6 ”
		died/2	
2.	4.12.56/27	8.12.56/ 7	4 days.
		9.12.56/11	5 ”
		10.12.56/3	6 ”
		died /6	
3.	6.12.56/31	10.12.56/7	4 days
		11.12.56/13	5 ”
		12.12.56/4	6 ”
		died /7	

Therefore the average of 60 nymphs shows that the time taken for the 1st moult was 4 days.

(ii) *The 2nd stage nymph*:— (Fig. 5)

The second stage nymphs were relatively more developed and stouter than the 1st stage nymph.

Measurements of various parts of the nymphs are given in Table VII (Average of 6 nymphs).

Table VII

Length of nymph	Width of abdomen	Width of thorax	Distance between compound eyes	Length of antenna	Length of rostrum
2.16 mm.	1.93 mm.	1.8 mm.	0.76 mm.	1.69 mm.	1.56 mm.

The first thoracic segment was slightly bent down in continuation of the rostrum. The general colouration of the body was darker than the first stage nymph. On the ventral side the margin of the segments were marked off by brown colour. There was a thin band of yellowish pink colour in each segment. On the dorsal side the thorax had become almost black in colour and had a median longitudinal yellowish line on all the three segments. The black bands previously three in number, were five now. They were more prominent and were occurring on the 2nd, 3rd, 4th, 5th and 6th abdominal segments. The first abdominal segment had two white spots in the middle, and a dark brown spot on either side at the margin. The last four abdominal segments had a dark coloured patch on the side margin (like the 1st abdominal segment). Apically the abdominal segments were telescoped.

On the 3rd day the nymphs were found actively feeding. On the 4th day they became sluggish. There was neither any increase in the dimensions nor any change in colour. It moulted at the end of the fourth day (Table VIII).

Table VIII

Date of 2nd moult together with the number of nymphs moulted where the upper figures indicate the date of moult and the lower the number of nymphs moulted.

No.	1st moult	2nd moult	Days taken to moult
1.	1.12.56/25	4.12.56/3	3 days
		5.12.56/9	4 ”
		6.12.56/5	5 ”
		died/8	

No.	1st moult	2nd moult	Days taken to moult
2.	6.12.56/13	9.12.56/1	3 days
		10.12.56/8	4 "
		11.12.56/3	5 "
		died/1	
3.	10.12.56/37	13.12.56/8	3 days
		14.12.56/11	4 "
		15.12.56/15	5 "
		died/3	

Therefore the average of 63 cases shows that the number of days taken for the 2nd moult was 4 days.

(iii) *The 3rd stage nymph:*—(Fig. 6).

The 3rd stage nymph was generally changed in habits. Its sitting posture was parallel to the ground. The last thoracic segment which was bent down so long, was somewhat raised up. It avoided light and was very active, mostly it was seen moving or feeding. The measurements of the various parts of the nymph are given in Table IX. (Average of 6 nymphs).

Table IX

Length of nymph	Width of abdomen	Width of thorax	Distance between compound eyes	Length of antenna	Length of rostrum
3.0 mm.	2.56 mm.	2.16 mm.	0.86 mm.	1.95 mm.	1.76 mm.

The colouration has also changed much. On the dorsal side the thorax had a median spot of white and pink colour in each segment and at the side margin the 2nd and 3rd thoracic segments had a pink coloured spot. The thorax was deep brown in colour.

The brown bands on the dorsal abdominal segments were now four and were 'V' shaped, the open arms of 'V' were directed towards posterior end of the nymph. The black bands were on 3rd, 4th, 6th and 7th abdominal segments on the dorsal side. The 1st, 2nd, and 5th segments had each a pair of white spots alternating the black bands. The white spot on the 2nd segment was the widest. The whole of the dorsal abdominal surface except the patches and the spots was of pink colour.

Ventrally all the abdominal segments had 2 lines of white and pink colour alternating each other. The mid ventral portion of all the abdominal segments were deep brown. The thoracic segments also had on the ventral side patches of white and pink colour but they were wider than the former. Both dorsally and ventrally the side margin of the abdominal segments had a dark brown patch on both the sides. Seven abdominal segments were clearly seen.

On the 2nd day feeding and the movements were normal, but the colouration was deeper and clearer. On the third day rudiment of wing pads were observed indistinctly developed at the lower margin of the last thoracic segment on both the sides of the median longitudinal line.

On the 3rd day the nymphs reared under both conditions had normal activities. On the 4th day it remained motionless in some hidden corner, did not suck the juice and kept away from the light. There was no increase in the size. It moulted after the 4th day (Table X).

Table X

Date of 3rd moult together with number of nymphs moulted where the upper figures in column 2 and 3 indicate the date of the moult and the lower the number of nymphs moulted.

No.	2nd moult	3rd moult	Days taken to moult.
1.	9.12.56/18	12.12.56/4	3 days
		13.12.56/2	4 ”
		14.12.56/7	5 ”
		died/5	
2.	11.12.56/18	14.12.56/1	3 days.
		15.12.56/5	4 ”
		16.12.56/9	5 ”
		died/3	
3.	15.12.56/9	18.12.56/1	3 days
		19.12.56/3	4 ”
		20.12.56/5	5 ”

Therefore the average of 37 cases shows that the time taken for the 3rd moult was 4 days.

(iv) *The fourth stage nymph*:—(Fig. 7)

The sitting position now became normal. In the middle of all the thoracic segments there was a pink spot, and two white spots on the two side margins. The measurements of various parts of the nymph are given in Table XI (Average of 6 nymphs).

Table XI

Length of nymph	Width of abdomen	Width of thorax	Distance between compound eyes	Length of antenna	Length of rostrum
4.06 mm.	3.03 mm.	2.66 mm.	0.89 mm.	2.49 mm.	1.98 mm.

The 3rd thoracic segment had clearly developed wing pads. They were prominent lobes on both the sides of the median longitudinal line. The lobes reached the posterior margin of the 1st abdominal segment. On the dorsal side the four bands were on the 3rd, 4th, 5th and 6th abdominal segments. The margin on the sides of all the abdominal segments had a black spot. The last segment was totally black in colour. Rest of the abdominal segments had white and pink coloured bands. Ventrally the colouration was of the same pattern as that of the previous moult. The mid ventral portion of all the segments had black bands and the side margins had a black spot. Rest of the ventral area was coloured white with bands of pink colour. There was no change in appendages and the tarsi persisted to be two segmented.

On the 3rd day the wing pads were of darker colour and thickened. The feeding was more frequent.

On the 4th day they spent most of their time in feeding. Movements were restricted. It moulted after the 4th day (Table XII).

Table XII

Date of 4th moult together with number of nymphs moulted where the upper figures in column 2 and 3 indicate the date of the moult and the lower the number of nymphs moulted.

No.	3rd moult	4th moult	Days taken to moult
1.	10.12.56/16	14.12.56/10	4 days
		15.12.56/4	5 "
		16.12.56/2	6 "
2.	17.12.56/19	21.12.56/8	4 "
		22.12.56/6	5 "
		23.12.56/3	6 "
		died/2	
3.	21.12.56/24	25.12.56/11	4 days
		26.12.56/7	5 "
		27.12.56/3	6 "
		died/3	

Therefore the average of 54 cases shows that the time taken for the 4th moult was 4 days.

(*v*) *The 5th stage nymph*:— (Figs. 8, 11 & 12).

The 5th stage nymphs could be categorised in two groups the males and the females. The females had the median streak (Fig. 11) a highly chitinized partition of the 6th sternite. It originated from the ventral boundry of the 7th sternite from the median position. The base of the streak is broad anteriorly deep in colour, highly chitinized and tapering posteriorly into the so called median streak. This streak bifurcates posteriorly along the posterior boundry of the 6th sternite. After bifurcation it is less chitinized and the bifurcated ends become quite indistinct gradually. The average length of the nymphs which moulted into adult females being 5.7. mm. had a proportionate body with somewhat lighter colour.

The males however possessed no such streak (Fig. 12). They were on an average 4.2 mm. long. They were stout and of slightly darker colour. They resembled each other in structure and general form. Antenna had the same number of segments as in the previous moult, but the rostrum had become 4 segmented. The terminal segment was divided into two which was not very clear with the naked eye, but it could be distinguished under the microscope. The hind margin of the 3rd thoracic segment had deep curves. The two corners were rounded and thickened. Its median longitudinal portion which formerly had a pink spot possessed a deep brown ridge. The upper surface of the thoracic area was not so smooth as it was before, but has become rough. The wing pads extended up to the 2nd abdominal segment. The colouration resembled that of the last day of the 4th moult. Only the black spots of the side margin had developed a pink spot within them. They had the black bands dorsally on the same 4 abdominal segments and the last segment was totally black. There being a marked difference it is convenient to describe them separately.

(A) *Smaller nymphs or the males*:—

As already mentioned they resembled the bigger nymphs. Measurements of various parts of the newly emerged nymph are given in Table XIII (Average of 6 nymphs).

Table XIII

Length of nymph	Width of abdomen	Width of thorax	Distance between compound eyes	Length of antenna	Length of rostrum
4.26 mm.	3.66 mm.	3.01 mm.	0.96 mm.	3.08 mm.	2.33 mm.

They had free and leisurely movements and frequent feeds. They usually remained under the leaves. If undisturbed they might be seen creeping on the leaves or moving swiftly. There was a gradual increase in dimensions on the following days. The movements and feeds were comparatively more. On the 4th day it was more or less a globular strucuture. The movements were less but feeding was frequent. It was mostly seen piercing the leaves here and there. It preferred to pierce the midvein to obtain the juice. On the 5th day there was no increase anywhere and the sizes remained the same.

It was mostly seen hidden under the leaves. It avoided light, did not feed and remained motionless.

(B) *Larger nymphs or the females:*—

Measurement of various parts of the newly emerged nymph is given in Table XIV (Average of 6 nymphs).

Table XIV

Length of nymph	Width of abdomen	Width of thorax	Distance between compound eyes	Length of antenna	Length of rostrum
5.76 mm.	3.70 mm.	3.36 mm.	1.10 mm.	3.13 mm.	2.34 mm.

On the following days there was an increase in the sizes and they could easily be marked out from the smaller nymphs. The gradual and regular growth was marked on the 4th day when the nymph was 6.01 mm. in length and 3.8 mm. in width. On the 5th day there was no increase and the size remained the same as on the 4th day. The activities of the larger nymph were the same as that of the smaller one. After the 5th day the nymphs (both smaller and larger) moulted into adults (Table XV).

Table XV

Date of 5th moult together with the number of nymphs moulted where the upper figures in column 2 indicate the date of moult and the lower the number of nymphs moulted, and the upper figures in column 3 indicate the date of moult and the lower the number of nymphs moulted into adults.

No.	4th moult	5th moult	Days taken to moult.
1.	19.12.56/28	23.12.56/9	4 days
		24.12.56/8	5 ”
		25.12.56/9	6 ”
		died/2	
2.	29.12.56/30	2.1.57/1	4 days
		3.1.57/9	5 ”
		4.1.57/2	6 ”
		died/18	
3.	1.1.57/21	5.1.57/4	4 days
		6.1.57/12	5 ”
		7.1.57/5	6 ”

Thus the average of 59 cases shows that the time taken for the 5th moult was 5 days.

(e) *The adult*:—(Fig. 9).

After the 5th moult the insect completed its life-history, which took 30 to 32 days. The smaller nymphs categorised above moult into the males and the bigger ones into females, the structure and colouration of both the sexes were the same. The male and female bugs could be differentiated in size (Table XVI).

Table XVI

Measurement of the various parts of the adults just emerged. (Average of 6 ♂ male and 6 ♀ female bugs)

Bugs:	Length of the bug	Width of abdomen	Width of thorax	Distance between compound eyes	Length of antenna	Length of rostrum
Female:	6.18 mm.	3.93 mm.	3.54 mm.	1.44 mm.	3.86 mm.	3.01 mm
Male:	4.43 mm.	3.30 mm.	2.90 mm.	1.21 mm.	3.36 mm.	2.40 mm.

The antennae which were 4 segmented now became 5 segmented. They were of dark brown colour and more hairy. The rostrum was 4 segmented as it was in the last moult also. Now they have developed two sickle shaped setae at the terminal end about 0.08 mm. long. The first segment of the rostrum was the largest, the second smaller and the last two smallest. The last two segments were more hairy, deeper in colour and equal in size. Sizes of the rostrum and antenna were different in both the sexes. The tarsi which were two segmented became three, and two terminal hooks persisted to be on the terminal segment. The colour and structure all resembled the adult insect. Usually the copulation was seen 1 to 2 days after the emergence of the adult.

SUMMARY

1. From 58 to 130 eggs were laid per female in 6 days.
2. On the 4th day the colour of the white spherical egg changed to pink, then brown by the 9th day after which it hatched.
3. The 1st stage nymph did not resemble the adult in size colour and in being wingless.
4. Interval between each moult was from 4 to 5 days.
5. In the 5th stage nymph striking changes occurred:—
    (i) Prominent wing pads developed.
    (ii) Rostrum so far 3 segmented became 4 segmented.
    (iii) Sexes were differentiated.
6. After the 5th moult the adults emerged having the following characters;—

(i) Tarsi instead of having 2 segments became 3 segmented.
(ii) Antenna which were 4 segmented became 5 segmented.
(iii) They were fully winged.

7. Life history was completed in 30 to 32 days.

ACKNOWLEDGEMENTS

The present work was done under the guidance of Dr. T. Singh Professor of Zoology and Entomology, St. John's College, Agra, to whom I am indebted not only for the necessary facilities, but for all encouragement and help. I should thank also Dr. A. P. Kapur, Officer In-charge, Entomology Section, Zoological Survey of India for identifying the insects.

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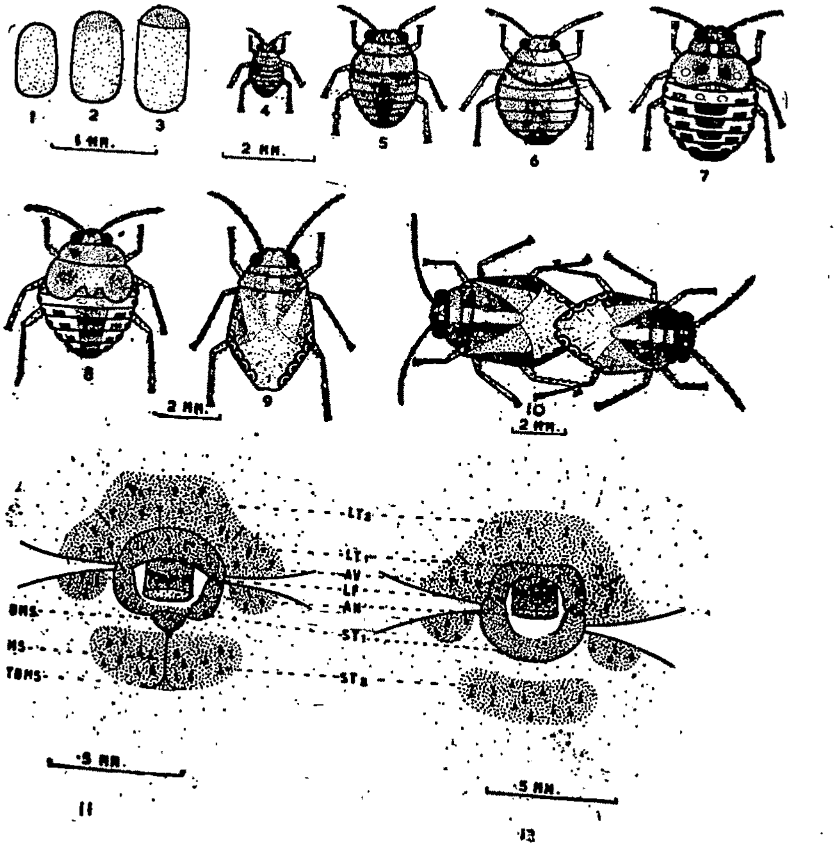
PLATE I



EXPLANATION OF THE PLATE

FIG. 1.	Freshly laid egg.
FIG. 2.	Egg 3 days old.
FIG. 3.	Egg just before hatching.
FIG. 4.	1st stage nymph.
FIG. 5.	2nd stage nymph.
FIG. 6.	3rd stage nymph.
FIG. 7.	4th stage nymph.
FIG. 8.	5th stage nymph.
FIG. 9.	The adult.
FIG. 10.	Copulating adults.
FIG. 11.	Genital segments of the female 5th stage nymph.
FIG 12.	Genital segments of the male 5th nymph.

Abbreviations

AN	Anal opening
AV	Anal plate.
BMS	Base of the median streak.
LF	Lateral fold.
LT 1	Tergite of the last abdominal segment.
LT 2	Tergite of the 6th abdominal segment.
MS	Median streak.
ST 1	Sternite of the last abdominal segment.
ST 2	Sternite of the 6th abdominal segment.
TBMS	Bifurcating terminal portion of the median streak.

CYTOLOGICAL STUDIES IN *Trachelomonas Grandis* SINGH[1]

By KAMALA P. SINGH, M.SC., PH.D. *Asstt. Professor of Botany, D.S.B. Govt. College, Nainital.*

INTRODUCTION

The systematic studies of the Genus *Trachelomonas* have been over-emphasized in the past, but the only accounts of its nuclear division appear to those of Wilson (1929) and Gimesi (1930) for *Trachelomonas volvocina* collected from nature. Because of the large size of the nuclei in *Trachelomonas grandis* Singh (Singh, 1956, p.259) and its luxuriant growth in unialgal culture, together with relatively little known cytology of the genus as a whole, the present investigation was undertaken, therefore, in an attempt to verify the previous works.

REVIEW OF THE LITERATURE

The Genus *Trachelomonas* belongs to the family Euglenaceae and is characterized by the possession of a conspicuous lorica or envelope which encloses the protoplast. The nuclei of this genus are usually large and prominent and seem to have the same general characteristics as those of other euglenoids. It contains a centrally located "caryosome" or "endosome" (probably similar to the nucleolus of many other organisms) and a number of chromatin granules distributed between the endosome and the nuclear membrane. Wilson (1929), however, reports the presence of two or more endosomes in *Trachelomonas volvocina.* The process of nuclear division has been studied very extensively in different species of *Euglena* (*E. viridis*, Tschenzoff (1916); *E. agilis*, Baker (1926); *E. spirogyra* Ehrbg., Ratcliffe (1927); *E. deses* Ehrbg., Gojdics (1934); *E. granulata* and *E. quartana*, Hollande (1942). The only accounts of nuclear division in *Trachelomonas* appear to be those of Wilson (1929) and Gimesi (1930) for *T. volvocina.* There seems to be a unanimity of opinion regarding the general course of mitosis in different species of *Euglena* and *Trachelomonas* studied. Opinions differ, however, regarding the mode and the time of chromosome reduplication.

During prophase, the chromatin granules are organized into distinct chromosomes which apparently become divided longitudinally. S. R. Hall (1931) and Gojdics (1934), however, report the transverse division of the chromosomes. This has been denied by Jahn (1946), according to whom the chromosome division definitely is longitudinal. Longitudinal division of the chromosomes has been reported to occur in prophase (Baker, 1926, *E. agilis*), metaphase (Hollande, 1942, *E. granulata*), anaphase (Ratcliffe, 1927, *E. spirogyra*) and in telophase (Tschenzoff, 1916, *E. viridis*) stages.

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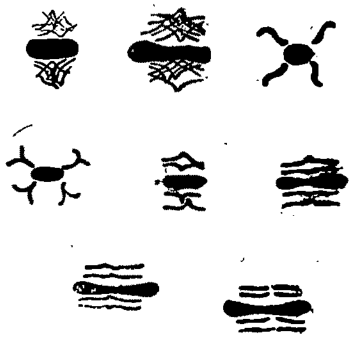
[1] From a dessertation submitted to the Graduate School of Vanderbilt University in partial fulfillment of the requirements for the degree of Doctor of Philosophy. This work was done at the suggestion and under the supervision of Professor Harold C. Bold, to whom I am especially indebted.

During metaphase, the endosome elongates and assumes an a symmetrical dumbbell-shape (Baker, 1926; Gojdics, 1934). The endosome divides into two, one portion going to each daughter nucleus. The endosome does not contribute obviously to the organization of the chromosomes. The chromosomes during metaphase lie parallel to and around the endosome and seem to form an equatorial plate (fig. A-1). The plate seems to consist of "V" and "Y"—shaped chromosomes. One arm of these double chromosomes is directed toward either pole. The "V" and "Y" chromosomes then unfold (fig. A, 2-8) so that one half goes to each pole (Baker, 1926).



TEXT FIG. A. Mitosis in *Euglena*. (After Hall, 1937).
1. Equatorial "plate" stage, optical section, somewhat diagrammatic.
2. slightly later stage, unfolding of V's is pronounced.
3-8, behaviour of chromosomes, hypothetical case with four chromosomes, showing longitudinal splitting.

Hollande (1942) reports that in *E. granulata* the chromosomes are formed in prophase and divide longitudinally during metaphase. The daughter chromatids twist about each other and give the appearance of meiotic chromosomes. The double chromosomes straighten and the chromatids move apart towards opposite poles during anaphase.

Wilson (1929) described nuclear division in *T. volvocina*, as similar in pattern to that described for *Euglena agilis* by Baker (1926). Gimesi (1930) makes a similar report for the same species of *Trachelomonas* but claims that one of the daughter nuclei is comparatively smaller than the other and that it stains more intensely.

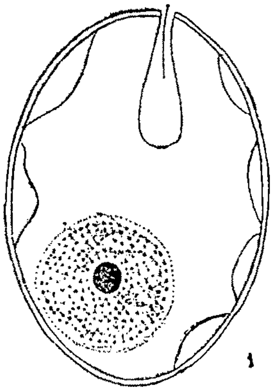
MATERIAL AND METHODS

The organism used in the present investigation was collected from a shallow pool in the vicinity of Nashville, Tennessee, U.S.A. and was grown in unialgal culture according to the methods of Pringsheim (1946, 1950). The organisms were fixed in 1 : 3 acetic acid-absolute alcohol at intervals of 1/2 hours during the night from 8 P.M. to 4 A. M. Most satisfactory material for stages of nuclear division was obtained at 12 midnight from week-old cultures.

The methods of staining, namely, Heidenhain's iron-alum haematoxylin and aceto-carmine were employed. The Feulgen technique was also used.

OBSERVATIONS

The nuclei in this species are somewhat variable in shape and size. It may be spherical or slightly irregular. It usually lies near the posterior pole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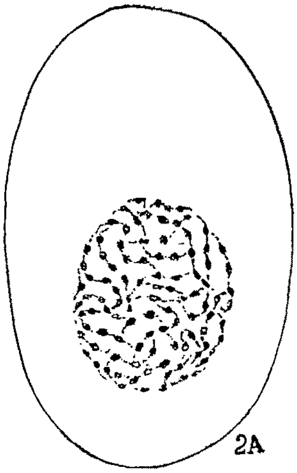
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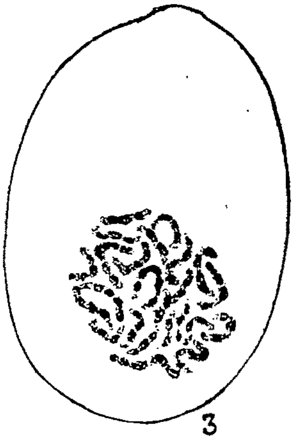
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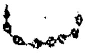
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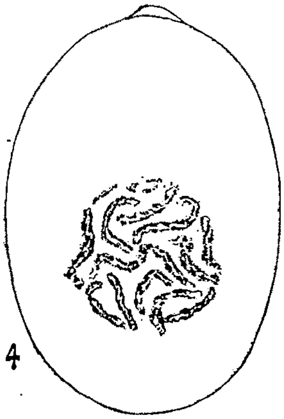
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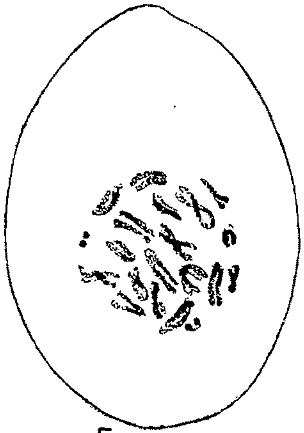
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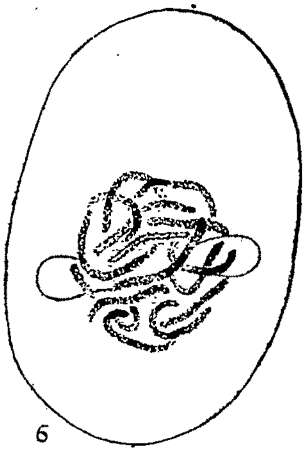
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FIG. 1.	Stained cell; note; the interphase nucleus containing an endosome. Haidenhain's ironalum haematoxylin. X 1258.
FIG. 2-6	Nuclear division, as observed in acetocarmine preparations, all in surface view.
FIG. 2A	Interphase. X 1700.
FIG. 2B	Individual strand from aquashed preparation. X 1700.
FIG. 3	Prophase. X 1700.
FIG. 4.	Later prophase, duality apparent. X 1700.
FIG. 5.	Still later prophase, chromatids twisted. X 1700.
Fig. 6.	Early anaphase, separation of chromatids by gliding; note elongated endosome. X. 1700.

of the cell. The interphase nuclei contain centrally located bodies, one in each nucleus (fig. 1), the endosome (nucleolus), which is ordinarily not visible in the living condition. The endosome stains very deeply with Haidenhain's iron-alum haematoxylin. There is some indication of slight migration of the nucleus from its lateral or posterior position toward the centre of the cell at the inception of the nuclear division. From examination of stained preparations, it is clear that with respect to nuclear condition, two general classes of cells are present. Some have nuclei with finely granular, dispersed chromatin, while others have nuclei with denser chromatin patterns. The nuclei of the first class are much larger than those of the other. It will be clear, from what follows, that the larger nuclei with dispersed granules are interphase nuclei which have not divided recently.

The interphase nucleus is characterized by containing a large number of beaded strands (figs. 2, 13) of chromatin. The crowded and tortuous disposition of the beaded threads makes it difficult to observe the limits of individual ones. This type of nuclear organization has been interpreted sometimes as consisting of granules of chromatin at the nodes of a linin network (Baker, 1926; Gojdics, 1934) and evidence of a network is visible in the writer's preparations. The individuality of such beaded threads can be followed easily and clearly in the peripheral region of the nucleus and still more clearly in smeared preparations (fig. 2 B). The interphase nucleus stains very lightly with Haidenhain's iron-alum haematoxylin, acetocarmine and the Feulgen technique. Visible evidence of the presence of a nuclear membrane is rare in all preparations.

The first evidence of the nuclear division is that the beaded threads begin to condense and shorten and, consequently, their stainable substance becomes more concentrated. As the condensation progresses, they assume the shape of the contorted threads or filaments, the chromosomes (fig. 3). Figure 3, a drawing of such a nucleus in surface view, does not depict adequately the complexity of the chromosome pattern. Further condensation and concentration result in the formation of clearly differentiated chromosomes (fig. 4), in which there is evidence of splitting. The nucleus now stains more heavily in all techniques than it does in the interphase stage or earlier prophases. While these changes are occurring, the nucleus enlarges slightly, and the endosome elongates in a direction at right angles to the long axis of the cell (fig. 6). The two chromatids of each chromosome then begin to separate and often produce complicated figures simulating those of meiosis (fig. 5). Later, these double chromosomes straighten out and their duality becomes still more clearly visible.

The chromatids which began to separate in the late prophase, now become completely separated (fig. 6). The resultant chromosomes at this stage are still quite elongate and their structure is homogeneous. The nucleus, which has retained its shape during the prophases, now elongates in a direction at right angles to the long axis of the cell.

As the anaphase progresses (figs. 7,8,14,15), it is clear that separation of pair of chromatids along their longitudinal axes is taking place. The migrating chromosomes again clearly exhibit duality during anaphase.

In the late anaphase (figs. 8, 15) or early telophase (fig. 9), the chromosomes arrange themselves in two groups around the enlarged ends of the endosomes. The continued elongation of the latter seems to carry the

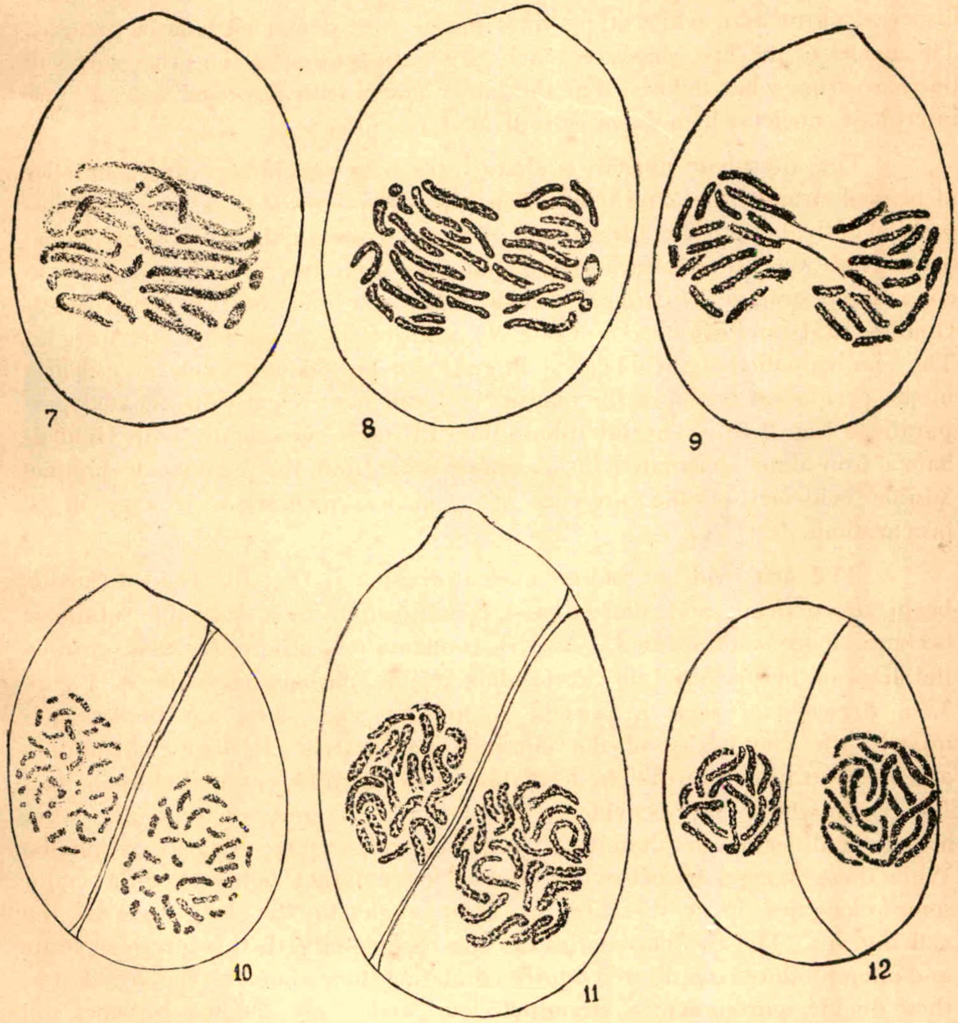
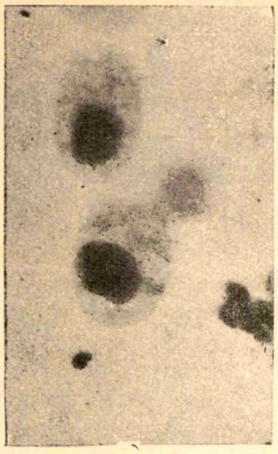


FIG. 7-12. Nuclear division, as observed in acetocarmine preparations, all in surface view.
FIG. 7. Later anaphase. X. 1700.
FIG. 8. Late anaphase, duality again visible. X 1700.
FIG. 9. Telephase; note bent endosome. X 1700.
FIG. 10. Late telophase and diagonal cytokinesis. X 1700.
FIG. 11. Equal-sized daughter nuclei. X.1 700.
FIG. 12. Unequal daughter nuclei; cell at left will leave lorica. X 1700.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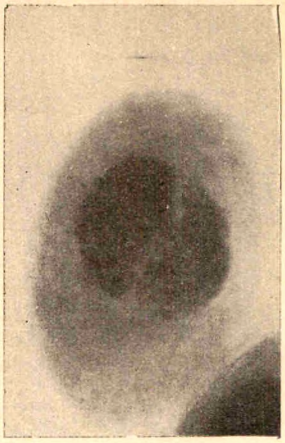
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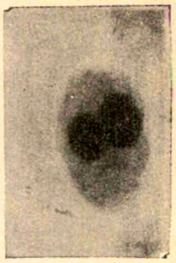
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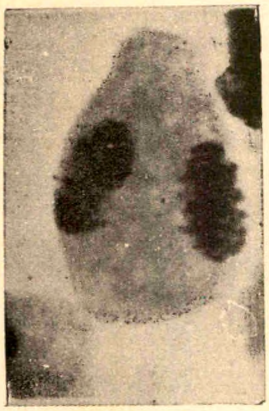
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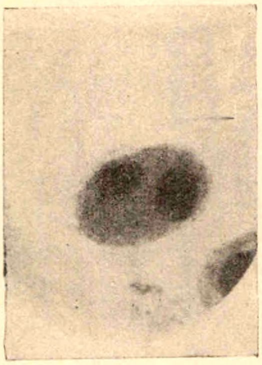
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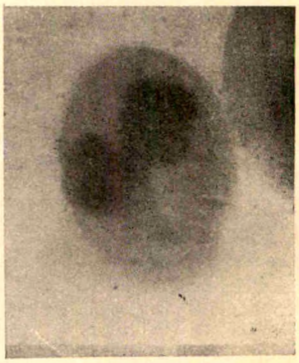
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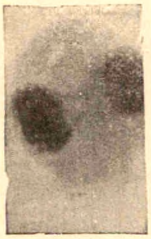
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FIG. 13. Prophase. X. 590.
FIG. 14. Early anaphase. X 1260.
FIG. 15. Late anaphase. X 590.
FIG. 16. Telephase. X 590.
FIG. 17. Similar specimen squashed. X 960.
FIG. 18. Interphase nuclei soon after division; note the unequal size of the nuclei X 960.
FIG. 19. Showing diagonal cytokinesis. X. 960.

two groups of chromosomes towards the cell surfaces (figs. 19,6). The endosome becomes narrower and may bend in the center (fig. 9). Its poles increase in size, probably at the expense of the central portion. The endosome eventually constricts in the middle and the two segments pull apart, one half going to each daughter nucleus. The endosomes finally regain the typical spherical shape. The shortening of the chromosomes progresses markedly and they become quite thick, but their duality remains quite clear.

By the time the daughter nuclei have been organized completely (fig. 10, 18) the chromosomes become still shorter and more dense. However, at a later stage (figs. 11, 12, 19), the chromosomal material begins to disperse. Ultimately, the chromosomes become somewhat contorted and drawnout into the beaded threads characteristic of the interphase nucleus. Nuclear size increases gradually during these processes.

Discussion

The methods of chromosome division, whether longitudinal or transverse, and the time of their reduplication in euglenoids, are controversial as indicated in the summary of the literature. The writer's aceto-carmine preparations clearly demonstrate that chromosome reduplication is linear and that separation of the chromatids is along the longitudinal axis. According to some investigators (Baker, 1926), reduplication of chromosomes occurs in prophase in *E. agilis*. Hollande (1942) states that it is at metaphase in *E. granulata*. Ratcliffe (1927) reports that it is at anaphase in *E. spirogyra* and Tschenzoff (1916) described telophasic duality in *E. viridis*. Careful observation of the writer's aceto-carmine preparations, in which the chromatin material undergoes maximum swelling, a technique not used by earlier investigators, reveals that the anaphasic chromosomes already give evidence of duality, and this persists into the telophases. Failure to observe duality in the threads of earliest prophase is probably the result of their extreme tenuity. As the prophase progresses, however, it becomes clear that the threads are double. The pairs of chromatids separate and very soon again become dual structures.

Summary

Nuclear division of *Trachelomonas grandis* Singh was studied in considerable detail. Chromosome reduplication is probably anaphasic. During nuclear division, the endosome elongates in a direction at right angles to the long axis of the cell, divides into two, and one portion goes to each daughter nucleus.

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A NOTE ON PROPAGATION OF LAGERSTROEMIA INDICA BY CUTTINGS WITH THE AID OF PLANT REGULATORS.

By P. N. Bajpai and A. S. Parmar, *Department of Horticulture, Government Agriculture College, Kanpur.*

It is easier as well as cheaper to raise plants by cuttings. But all plants do not strike roots easily and hence they are treated with the plant regulators before planting. Stoutemyer (1939) using 20 parts per million of indole-acetic acid in acquous solution on *Lagerstroemia indica* cuttings has reported 40% success in the treated and 30% under control. The present investigation was undertaken to find suitable concentration of two plant regulators and the types of cuttings for rooting *L. indica.*

Material and Method

Watkins (1940) found that the presence of leaves on semi-hard-wood cuttings was a ready means of propagating plants. Fourteen cuttings 'with' and 'without' leaves were made from branches above five months old in the rainy season for each treatment. The experiment was repeated in the spring season but as the cuttings 'with' leaves were not available so semi-hard-wood and hard-wood cuttings were obtained.

The average diameter and the length of the cuttings was 0.65 cm. and 19 cm. respectively. The plant regulators used were Indole 3-acetic acid (I.A.A.) and Naphthalene acetic acid (N.A.A.) and the concentration of the solutions was 0.02% and 0.04% in each case. The basal ends of the cuttings were dipped to a height of about 1″ from the cut end in these solutions for 24 hours. After this they were washed in distilled water and planted in sand. One set of the cuttings was dipped for the same length of time in pure distilled water to serve as control.

The data given in table I shows the percentage of success

TABLE I

Showing percentages of success in rainy season and repeated spring season experiments.

Plant regulators	Concentration	Treatments.	Spring season hardwood cuttings without leaves 18th week A	Rainy season hardwood cuttings without leaves 5th week B	Rainy season hardwood cuttings with leaves 5th week C	Semi hardwood cuttings in spring season on the 18th week D
Indole-acetic Acid.	0.02%	1	14%	14%	21%	7%
	0.04%	2	42%	35%	63%	21%
Naphthalene-acetic acid	0.02%	3	35%	35%	37%	14%
	0.04%	4	21%	21%	28%	7%
Control		5	0%	0%	7%	0%

From the above table as well as Fig. I, it is clear that in the rainy season, the hardwood cuttings with leaves and with 0.04% of I.A.A. resulted in 63% rooting while there was only 35% rooting in case of hardwood cuttings without leaves.

But when we compare the results of hardwood cuttings without leaves of spring with that of the rainy season, we find nearly similar results except that in the spring season, they took about 18 weeks to root and this may be due to the low humidity as well as low temperature prevailing in the spring months. It seems that semi-hardwood cuttings in Lagerstroemia are not suitable in spring for propagation because they gave very poor rooting in all treatments.

SUMMARY

1. Indoyle 3-acetic acid and Naphthalene acetic acid gave similar results with hardwood cuttings without leaves in both the seasons.
2. 0.04% of I.A.A. gave 63 % rooting in cuttings with leaves while with N.A.A. the rooting was only 28%.
3. Cuttings with leaves are superior to cuttings without leaves for propagation in Lagerstroemia.

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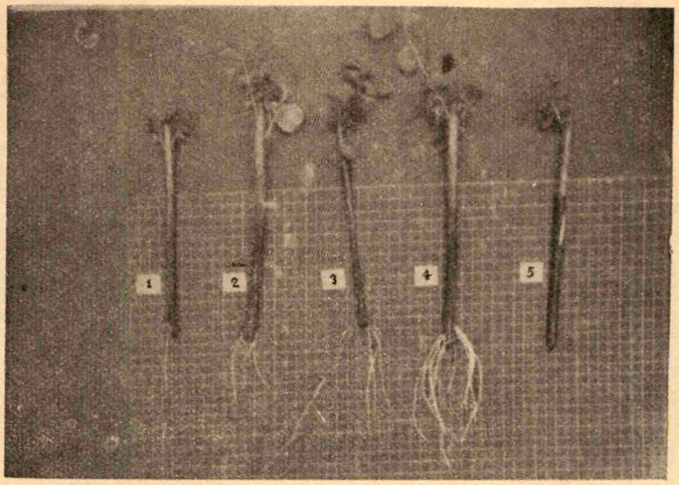
EXPLANATION OF FIG. 1

Showing the number of roots and root length in cms. with different treatments in *Lagerstroemia indica*. (Rainy Season (Crop).

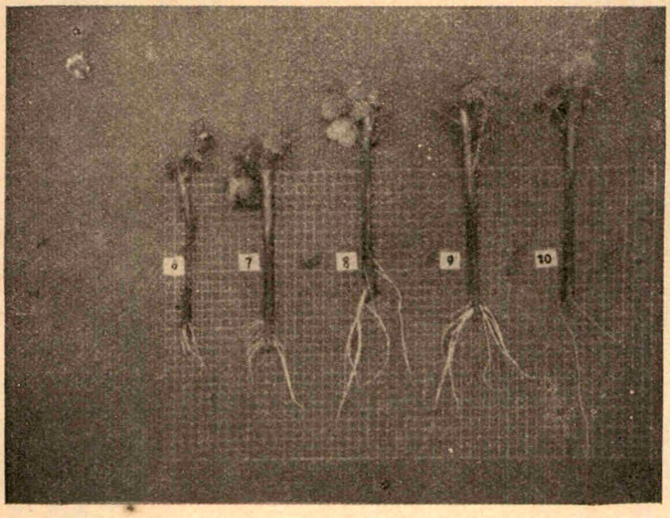
I. A. A.			N. A. A.		
0.02%	'0.04%		0.02%	'0.04%	
1a' 2b	'3a '4 b	Control	6a '7b	8a '9b	Control
		5			10

(a) Hard wood cuttings without leaves.

(b) Hard wood cuttings with leaves.



1a 2b 3a 4b 5



6a 7b 8a 9b 10

INFLUENCE OF PROPOGATING MEDIA ON ROOTING IN CUTTINGS OF LANTANA SPECIES

By O. S. Jauhari, M. Sc. (Ag.), S. S. Saxena, M. Sc., Ph. D. and
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Studies relating to root production in cuttings have been conducted by numerous investigators over a period of many years. As a result of these investigations, many fundamental facts have been established regarding relationships between the cuttings and its environment. It has also been reported that pH of the propagating media does influence the initiation and formation of roots in cuttings, but the same polarity of medium does not suit all the plants.

Chadwick (1930) reported that there is a definite co-relation between the acidity of the medium and the rooting of cuttings of *Juniperus horizontalis plumosa.* Working on *Thuja* cuttings, he has mentioned that all varieties of *Thuja* do not react the same way when propagated in different media. Sand is a good medium for most varieties of *Thuja occidentalis* but the rooting of *Thuja plicata* is influenced by the acidity of the medium.

Longley (1930) using 4 types of peat of varying acidity and structure and 3 sands of varying firmness and acidity in various concentrations as propagating media indicated that the acidity of the medium has some influence in promoting rooting, but the relation was not constant. Longley also showed a wide variation for different plant material while working on rooting in cuttings of 30 widely different ornammental plants under12 different sets of conditions. The pH value ranged from 3.9 to 8.8.

Hitchcock and Zimmerman (1926) obtained better rooted cuttings of *Azalea amoena* in acid peat moss than in sand. California privet cuttings rooted well in sand, but poorly in acid peat moss. Considerable variation in rooting response resulted when both were placed in neutral leached peat moss.

Smith (1926) found pH 7.0 to be optimal for root production with *Coleus* cuttings.

Esper and Roof (1931) tested many species on the mixture of sand and peat, peat and slag and found that slightly acidic medium is more appropriate for rooting.

Small (1923) tested the effect of adding dilute acetic acid (1 : 10,000) to coconut fibre and to soil, and reported an increased percentage of rooting, or a reduction in time required for rooting. On the other hand, Veirheller (1923) failed to improve the rooting of apple cuttings when acid treatment was used. Phillips (1926) likewise obtained no marked improvement by addition of acid in rooting of *Ocotea bullata* cuttings.

Zimmerman (1925) stated that peat moss stimulated rooting in *Ilex*, Delaware grape and some *Viburnum* cuttings.

Hitchcock (1928), concluded that pH of the medium is also an important factor in determining the type of rooting and found that cuttings of *Rhododendron maximum* formed excellent root system in pH 6 - 7.6 maintained in leached peat moss.

Proper media for rooting of cuttings is of prime importance, but McCollum (1905) emphasised that nutrient conditions are the principal factors governing root formation. Schindler (1932) tested cuttings of deciduous fruit tree rootstocks in various cultural media differing in their reaction and obtained best results with a complete cultural solution rich in nitrogen. Haas (1937) found good results in *Avocado* cuttings when sprayed for a week with a complete cultural solution rich in nitrogen. Grace (1939) made weekly applications of Hogland's solution to cuttings of Norway spruce, and found a great increase in the number rooted and their growth. Whereas, Thimann and Poutasse (1941) working with leaf cuttings of *Phaseolus vulgaris* in solution culture, found that a complete nutrient solution generally retarted root formation.

With the above ideas in view, *Lantana* cuttings, which are easy-to-root, were selected for experimentation under three levels of pH, i.e. pH 5·0, pH 7.0 and pH 9.0 and each with and without nutrients. These experiments were carried out during the months of November 1953 to April 1954, in the glass house attached to the Botanical Laboratory of the Govt. Agricultural College, Kanpur.

METHODS AND MATERIAL

Treatments.

A. No nutrients.	Tap Water.
B. With nutrients.	Shive's 3-salt nutrient solution prepared according to Loomis and Shull, 1937.

Hydrogen-ion concentration:

1. pH 5.0	Acidic medium.
2. pH 7.0	Neutral medium.
3. pH 9.0	Alkaline medium.

Glacial acetic acid and sodium hydroxide were used to adjust the acidity and alkalinity of the medium. H-ion concentration was tested by Marconi Electric pH meter.

The cuttings were planted according to the following schedule:—

TIME OF PLANTING

(1) 18th November, 1953.
(ii) 18th December, 1953.
(iii) 18th January, 1954.
(iv) 18th February, 1954.

After six weeks of shooting and rooting in *Lantana*, the cuttings were taken at random, and the weights are the averages of 5 cuttings.

Five one-year old cuttings of as uniform a size as possible (about 9″ in length, and 0.7 cm. to 1.0 cm. in diameter) were selected, waxed and planted on each of the planting dates in 150 c.c. of the test solution filled in glass tumblers, which were painted black up to 4″ from the bottom. The tumblers, along with the cuttings, were then placed in the glass-house.

Test medium for the growth of the cuttings was changed bi-weekly, and the media were aerated every morning with the help of a pump.

After six weeks, the shoots and roots were separated from the cuttings with the help of a sharp knife, and their fresh weights were determined. Immediately after, the shoots and roots were placed in an oven to dry at 100°c., till the weight was constant. After the samples had dried, their dry weight was recorded.

OBSERVATIONS

The average fresh weight of the shoots formed per cutting is given in Graph 1.

Lantana cuttings show the best shoot formation in a neutral medium, while the alkaline range does not do as much harm as the acidity of the medium. The shoot formation is improved by adding nutrient solutions at all the levels of pH and at all the times of planting. Best shoot formation is exhibited in 18th December planting, and the most suitable pH is 7.0. Shoot formation also shows maximum increase due to the addition of nutrients in 18th December plantings. 18th January and 18th February plantings show on an average least shoot formation.

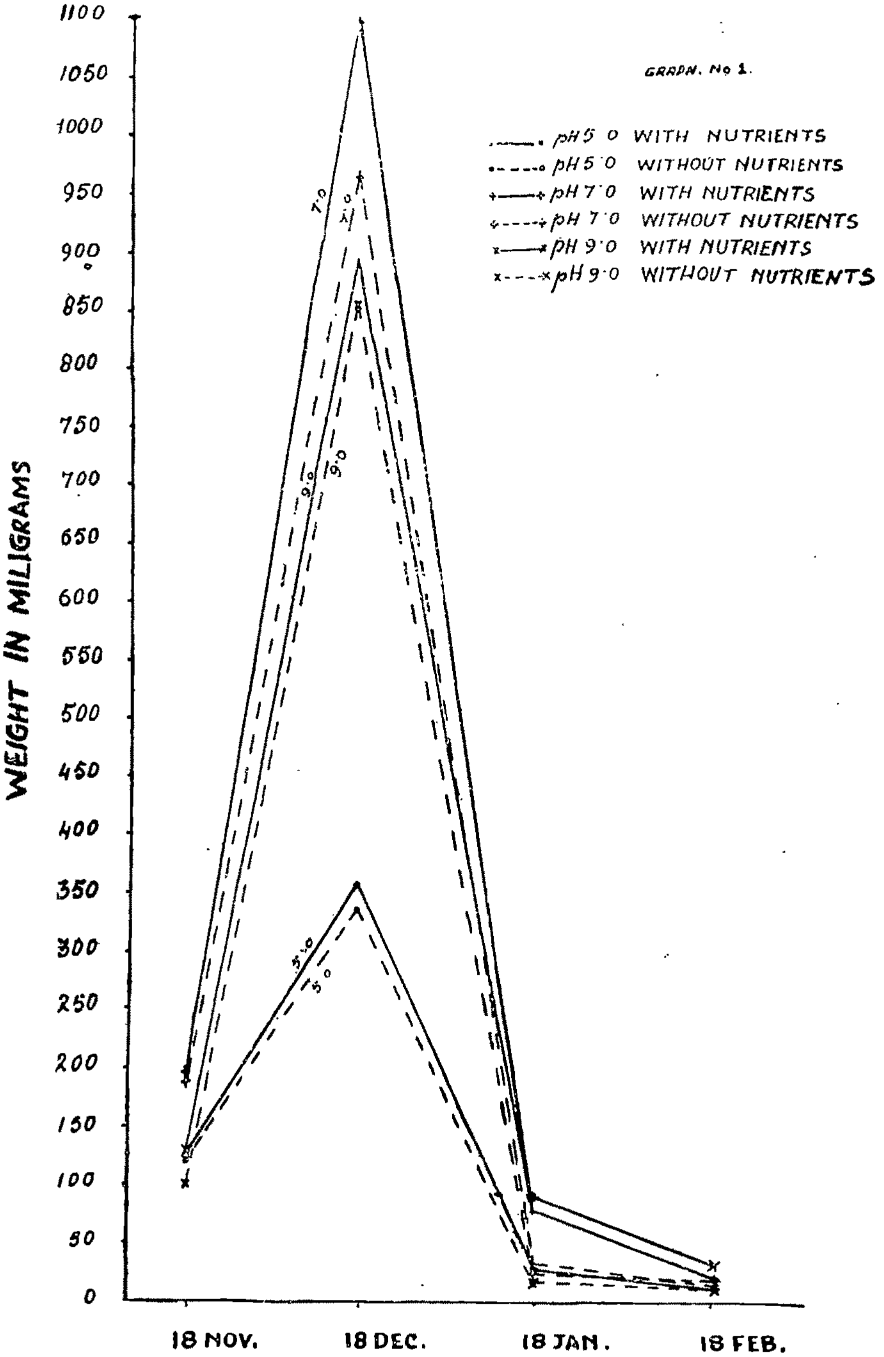
The dry weight of shoots is represented in Graph No. 2

Dry weights of shoots are highest at 7.0 pH with nutrients, followed closely by pH 9.0 with nutrients, while its counterpart, with nutrients, occupies a still lower position, being the third. In 18th December plantings, which shows the highest dry weights throughout, and in subsequent plants of 18th January and 18th February, pH 5.0 shows lowest dry weights, but here again the advantage of nutrient solution in increasing the dry weight of shoots is quite apparent.

18th December planting shows the highest dry weight of shoots, as compared to all others, and the second position is occupied by 18th November planting. The subsequent plantings of 18th January and 18th February show progressively decreased dry weights.

The average fresh weights of roots are given in Graph 3.

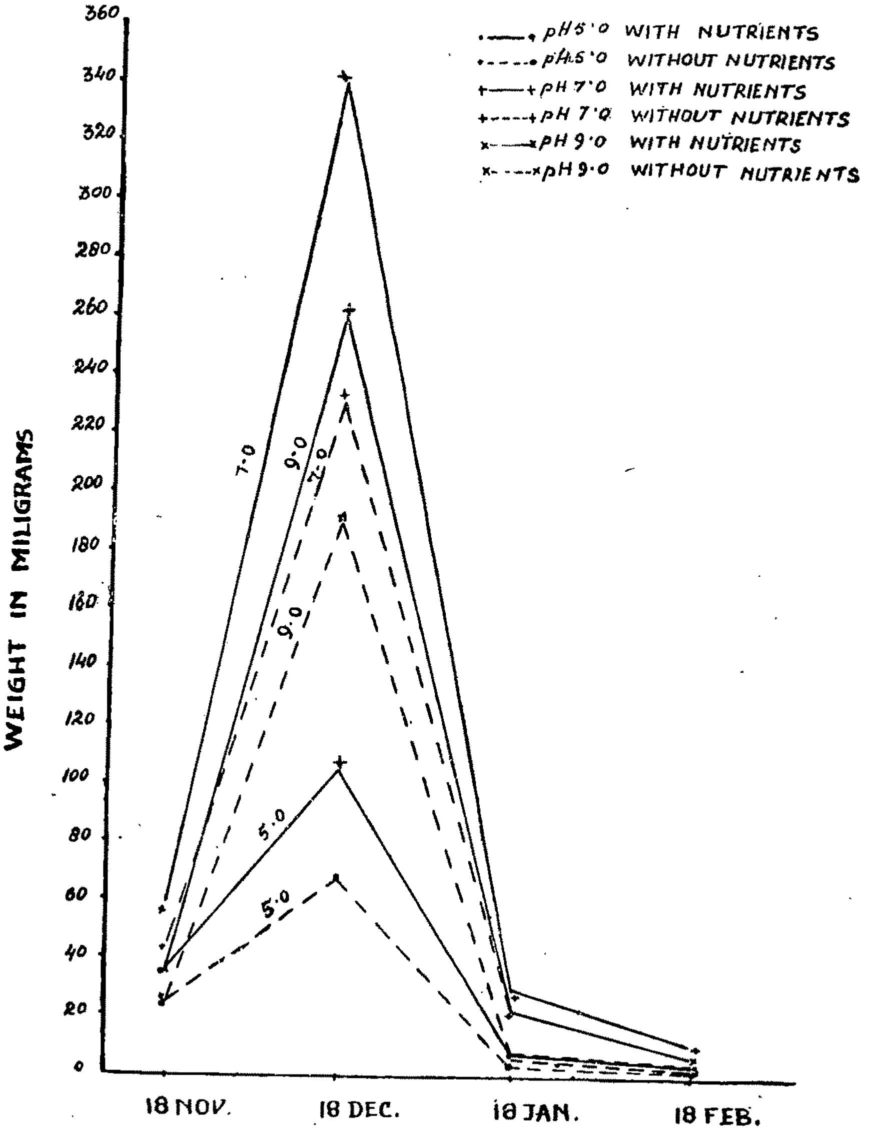
Best root production has been exhibited by the plantings at 7.0 pH. pH 5.0 shows least root production in the planting of 18th November, and the subsequent platings show no emergence of root at all at this pH. pH 7.0 in the first two plantings shows best root production when no nutrients are added,



GRAPH SHOWING FRESH WEIGHT OF SHOOTS WITH & WITHOUT NUTRIENTS IN LANTANA CUTTINGS.

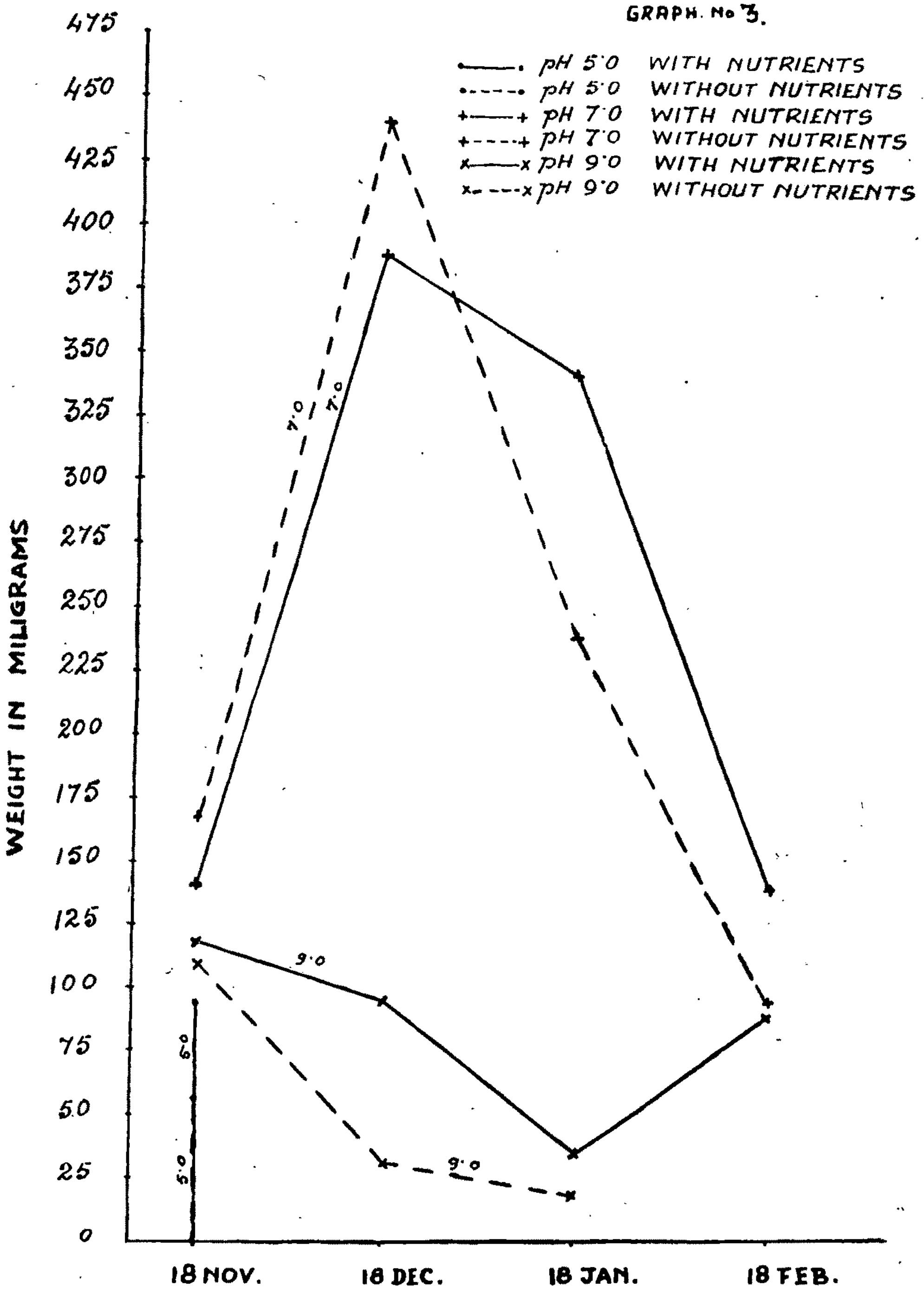
but in the last two plantings, the addition of nutrients shows a better root production. pH 9.0 is intermediate in root production, but lags far behind

GRAPH No 2.



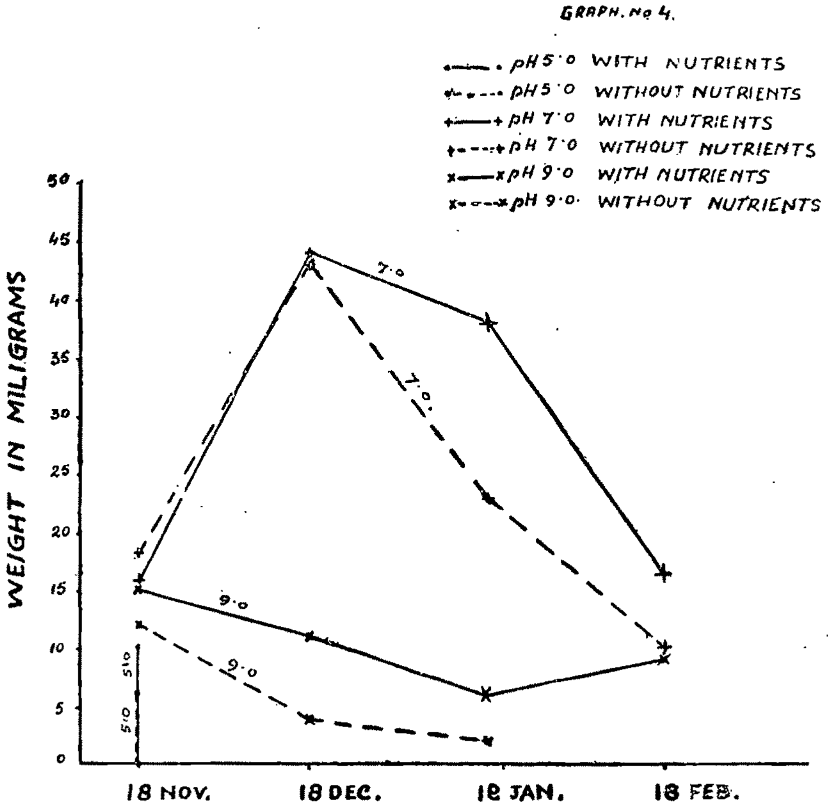
GRAPH SHOWING DRY WEIGHT OF SHOOTS WITH & WITHOUT NUTRIENTS IN LANTANA CUTTINGS.

the pH 7.0. This shows that neutral medium is best for root production.



GRAPH SHOWING FRESH WEIGHT OF ROOTS WITH & WITHOUT NUTRIENTS IN LANTANA CUTTINGS.

The average dry weights of roots formed under various pH levels under the experiment are given in Graph No. 4.



GRAPH SHOWING DRY WEIGHT OF ROOTS WITH & WITHOUT NUTRIENTS IN LANTANA CUTTINGS.

As regards dry weight of roots, it shows, more or less, the same trend as shown by fresh weights.

Discussion

The general belief that the most suitable medium for rooting in cutting should be neutral in reaction, has been found to be true in case of *Lantana*. Rooting in Lantana has given most promising results in neutral medium (pH 7.0) as compared with acidic medium (pH 5.0) and alkaline medium (pH 9.0). Thus the view of Esper and Roof (1931), Longley (1936), Hitchcock and Zimmerman (1926) and several other workers that the rooting is promoted by the acidity of the propagating media does not hold good in this particular shrub. On the contrary, the alkaline medium of pH 9.0 has proved better than the acidic medium. It seems to be a special case with *Lantana* which is supposed to be a very hardy and resistant shrub.

During the period under trial, 18th December plantings, have given the most encouraging results as regards fresh and dry weights of shoots and roots. This is decidedly due to prompt initiation of sprouts in the cuttings. This prompt and abundant sprouting in turn aids to establish the photosynthesis, transmission of certain auxins and also the supply of the organic material for growth and, thus, greatly helped in obtaining increased root production.

18th January plantings have shown next best root and shoot production. The weather temperature, till then, had not gone up to the extent, where it could materially hinder the activity of the root initials present in the cuttings. It can, thus, be confidently said that lower temperature does not only favour, but accelerates the root and shoot formation in *Lantana* cuttings. Earlier sprouting as an indication of favourable conditions of growth can also be taken as an effective means of rooting in cuttings. Esper and Roof (1931) working with *Coleus* cuttings found that greatest leaf area produced largest amount of roots.

In general, the addition of nutrient solution has significantly increased the shoot and root production in cuttings under all pH levels, and has, to some extent, masked the beneficial effect of the pH especially increase of the dry weights, indicating that the adverse effect of higher temperatures on root production is felt more by the plants which are not provided with the nutrient solution as compared to those provided with the nutrient solution.

Though Thimann and Poutasse have reported that a nutrient solution retarded root formation in the leaf cuttings of *Phaseolus vulgaris*, yet beneficial effects in rooting by application of cultural solutions rich in nitrogen have been found by McCollum (1905), Schindler (1932), Haas (1937) and Grace (1939).

SUMMARY

(1) The best time of planting *Lantana* cuttings is near about 18th December, both as regards the dry and fresh weight of shoots.

(2) *Lantana* cuttings can tolerate alkalinity.

(3) Addition of nutrients shows increase in fresh and dry weights of shoots at all the levels of pH. In case of dry weights, the addition of nutrients surpasses the beneficial effect of pH.

(4) Best root production has been shown at 7.0 pH, both with and without nutrients.

(5) Root production declines with the increase of hydrogen or hydroxylions in the rooting media.

(4) 18th December planting favours root production and the shoot production is also greatly improved, thus rendering the period quite suitable for planting cuttings.

(7) Under the conditions of experiment pH 7.0 was established to be the best for planting *Lantana* cuttings, both as regards shoot and root production.

It is possible to have a better medium somewhere between the range of 7.0 and 9.0 pH which may favour both root and shoot production.

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SOME HOLOTHURIANS FROM FLORIDA IN THE COLLECTION OF THE ALLAN HANCOCK FOUNDATION

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In the Spring Semester of 1950 when the writer was preparing to return to the Philippines, after working out the Eastern Pacific Holothurioidea in the collection of the Allan Hancock Foundation, University of Southern California, in Los Angeles, California, Dr. Irene McCulloch of the Foundation requested him to go over the collection of holothurians from Florida. This gave the writer a chance to study different groups of materials from the Atlantic Ocean for the first time. After working them out it was found that the following species were also recorded from the Indo-Pacific region:

1. *Holothuria atra* Jaeger
2. *H. cubana* Ludwig
3. *H. arenicola* Semper
4. *H. glaberrima* Selenka
5. *H. surinamensis* Ludwig
6. *H. impatiens* (Forskal)
7. *Stichopus badionatus* Selenka
8. *Phyllophorus zacae* Deichmann
9. *Euapta godeffroyi* (Semper)
10. *Polyplectana kefersteinii* (Selenka)

The presence of the said species in the other side of the world is possible because of the water connection of the two oceans through Central America during the Paleozoic, Mesozoic, and Tertiary periods, as well as during the Eocene, Oligocene and Miocene when the direct connection existed without interruption. The southern end of South America is another possible connection of the two large bodies of water where the pelagic embryos of the different species may have been carried by the current.

The following species described below constitute the main bulk of the collections of Holothurioidea from Florida. They are represented by three orders, namely *Aspidochirota*, *Dendrochirota* and *Apoda*. Order *Aspidochirota* is represented by 3 genera, namely *Holothuria*, *Actinopyga* and *Stichopus*. The genus *Holothuria* is represented by 10 species and the other two genera by one species each. The second order *Dendrochirota* is represented by 5 genera, namely *Phyllophorus*, *Neothyone*, *Leptopentacta*, *Ludwigia* and *Thyone*. The genus *Phyllophorus* is represented by 2 valid species, *Neothyone* by one variety, *Leptopentacat* by one species and two varieties, *Ludwigia* by one species and *Thyone* by 6 valid species. The third order, *Apoda*, is represented by 2 genera, namely *Euapta* and *Polyplectana*, each of which has one valid species.

Order ASPIDOCHIROTA Grube, 1840
Family HOLOTHURIDAE Ludwig
Subfamily HOLOTHURINAE Ludwig
Genus HOLOTHURIA Linnaeus 1758

1. *Holothuria atra* Jaeger
2. *H. floridana* Pourtales
3. *H. mexicana* Ludwig
4. *H. grisea* Selenka
5. *H. cubana* Ludwig
6. *H. arenicola* Semper
7. *H. glaberrima* Selenka
8. *H. surinamensis* Ludwig
9. *H. tubolosa* Gmelin
10. *H. impatiens* (Forskal)

Genus ACTINOPYGA Bronn

11. *Actinopyga agassizi* (Selenka)

Genus STICHOPUS Brandt 1835

12. *Stichopus badionatus* Selenka

Order DENDROCHIROTA Grube, 1840
Family PHYLLOPHORIDAE
Genus PHYLLOPHORUS Grube 1840

13. *Phyllophorus zacae* Deichmann
14. *P. occidentalis* Ludwig

Family CUCUMARIDAE
Genus NEOTHYONE Deichmann 1941

15. *Neothyone capensis* (Theel) var. *trojani* Domantay

Genus LEPTOPENTACTA H. L. Clark 1938

16. *Leptopentacta deichmannae* Domantay
17. *L. nova* Deichmann var. *floridana* Domantay
18. *L. nova* Deichmann var. *gemmata* Domantay

Genus LUDWIGIA Panning

19. *Ludwigia americana* Domantay

Genus THYONE Oken 1815

20. *Thyone pervicax* Theel
21. *T. pseudofusus* Deichmann
22. *T. fusus* (O. F. Muller)
23. *T. floridana* Domantay
24. *T. clarki* Domantay
25. *T. tenella* Selenka

Order APODA Brandt
Family SYNAPTIDAE Ostergren
Genus EUAPTA Ostergren

26. *Euapta godeffroyi* (Semper)

Genus POLYPLECTANA H.L.Clark

27. *Polyplectana kefersteinii* (Selenka)

HOLOTHURIA ATRA Jaeger

Holothuria atra Jaeger 1833, p. 22; Selenka 1867, p. 327, Pl. 18, figs. 52-53; 1868, p. 250; Semper 1868, pp. 88, 250, 278, Pl. 26; 1869, p. 120; Ludwig 1881, p. 596; 1882, p. 137; 1883, p. 170; 1887b, p. 32; 1887d, p. 1217 1887e, p. 1244; 1899, p. 559; Bell 1884, p. 510; 1886, p. 28; 1887a, p. 140; 1887c, pp. 654, 657; 1888, p. 389; Lampert 1885, p. 84; 1896, p. 55; Theel 1886a, pp. 181, 213, Pl. 7, fig. 4; Sluiter 1887, p. 188; 1894, p. 103; 1889-92, p. 329, Pl. 3, fig. 30, Pl. 6, fig. 6; 1895, p. 78; Saville-Kent 1893, pp. 49, 55, 102, 121, 234, 238, Pl. 33b; Studer 1893, pp. 191, 234; Koehler 1895a, p. 382; Whitelegge 1897, p. 161; 1903, pp. 8, 13; Hedley 1899, p. 530; Clark, H.L. 1901a, p. 495; 1902b, p. 530; 1920, p. 148; 1921, p. 174; 1923, p. 421; 1925, p. 102; 1932, p. 231; Voltzkow 1902, p. 565; Konningsberger 1904, p. 47, Pl. 8, fig. 2; Gardiner 1904, p. 339; Edwards 1905, p. 383; 1908a, pp. 537-540; 1908b, pp. 236-301, Pl. 1-5; Herdman 1906, p. 447; Fisher 1907, p. 657, Pl. 70, fig. 2; Koehler and Vaney 1908, p. 5; 1910, p. 101; Pearson 1910a, p. 176; 1913, p. 67, Pl. 9, fig. 11; Mitsukuri 1912, p. 64, text-fig. 14; Erwe 1913, p. 374, Pl. 6, fig. 14; Brooke 1927, p. 164; Panning 1928a, p. 221; 1935, p. 30, text-fig. 22; Stephenson, T. et al 1931, pp. 45-50, 55; Baker 1929a, pp. 141-143; 1928b pp. 167-171; Engel 1933, p. 4, Pl. 1, fig. 1, text-fig. 1-6; Domantay 1953a, pp. 110-112; 1953b, pp. 135, 140; 1954, pp. 337, 339-340.

Holothuria radackensis Chamisso and Eysenhardt 1821, p. 352, Pl. 26.

Holothuria amboinensis Semper 1868, pp. 92, 279.

Holothuria atra Jaeger var. *amboinensis* Theel 1886a, p. 214; Bedford 1898, p. 839, 1899 p. 147.

Holothuria sanguinolenta Bell 1893; Domantay 1933, p. 73, Pl. 3, fig. 3.

Body cylindrical, large size, measuring 200 mm. long × 60 mm. diam. Mouth and anus terminal. Tentacles retracted. Pedicels scattered all over the body, more conspicuous and crowded on the ventral side. Body-wall tough and thick. Color in preserved state dark brown almost black.

Deposits :

Simple tables, characteristic of the species, with spire composed of 4 pillars and 2 cross-beams, each pillar terminates in 3 spines or teeth. Numerous rosettes, more or less symmetrical from simple to fully formed ones resembling perforated plates. Pedicel with regular end-plate and supporting rods perforated at both ends.

Specimens examined:

Acc. No. —Locality	*Individual No.*
AHF-LM-18: Florida	2

HOLOTHURIA ARENICOLA Semper

Holothuria arenicola Semper, 1868, p. 61, Pls. 20, 30, fig. 13; Pl. 13, fig. 4; Theel1886, p. 222; Deichmann 1930, pp. 66-68, Pl. 4, figs. 1-9.

Holothuria subditiva Selenka 1867, p. 338, Pl. 19, fig. 87 (partim.)

Holothuria rathbuni Lampert 1885, p. 73; Theel 1886, p. 268; Clark, H.L. 1901a, p. 343; 1901b, p. 259, Pl. 37, figs. 7-10; 1919, p. 63; Verrill 1901, p. 37, figs. 6a, b; 1907, p. 145, fig. 37; Sluiter 1910, p. 332; Deichmann 1926, p. 13.

Body cylindrical, tapers at both ends. Medium size. Mouth and anus terminal. Pedicels scattered all over body in five indistinct bands, those on the ventral side clearer. Tentacles retracted. Color in preserved state grayish brown all over with two series of purplish blotches on the dorsal side. In general color pattern variable, some without blotches of darker color.

Deposits:

Tables and buttons. Tables with almost circular disk with one large central hole and several small marginal ones ranging from 4 to 12. Spire low, tapering distally with 2 cross-beams and terminate in small spinous crown with 8-12 spines. Buttons numerous, mostly regular and smooth with 3 pairs of oval holes, some are asymmetrical and with more holes. Pedicels with regular end-plate and numerous supporting rods ranging from simpler form with the middle and both ends dilated and perforated to regular huge button-shaped plate.

Specimens examined:

Acc. No. —Locality		*Individual No.*
AHF-A50-39:	Florida	2
AHF-A30-39:	”	1
AHF-A8-39:	”	1

HOLOTHURIA CUBANA Ludwig

Holothuria cubana Ludwig 1875, p. 28, Pl. 7, fig. 34; Theel 1886a, p. 237; Brooke 1927, p. 164; Deichmann 1930, p. 54, Pl. 1, figs. 1-8.

Body cylindrical, medium size measuring 75 mm. long × 15 mm. diameter. Mouth ventral and anus terminal. Small peltate tentacles partly retracted, apparently 20 in number. Pedicels scattered all over body, numerous and prominent on ventral side, fewer and less conspicuous, almost retracted on dorsal. Integument rough and hardy. Color in preserved state dirty white with sign of double series of faint brownish blotches on dorsum.

Deposits:

Tables and buttons. Tables somewhat massive and reticulated with whorled knobbed spire, and massive perforated knobbed disk. Marginal edge of disk knobbed. Numerous heavily knobbed buttons with 3 or more pairs of holes. Pedicels with regular end-plate and plate-like supporting rods dilated and perforated at the middle and at both ends with a ridge along the entire axis.

Specimens examined:

Acc. No. —Locality	*Individual No.*
AHF-A56-39: Florida	1
AHF-A50-39: "	2

HOLOTHURIA FLORIDANA Pourtales

Holothuria floridana Pourtales 1851. p. 8; Selenka 1867, p. 324, Pl. 18, figs. 47-49 (partim); Edwards 1905, p. 383 (partim); 1908, pp. 254-301, Pls. 1-5 (partim); Clark, H.L. 1919, p. 63 (partim); Deichmann 1930, p. 72, Pl. 5, figs. 5-9; Panning 1935, p. 32, fig. 25.

Holothuria heilprini Ives 1891, p. 318, Pl. 8, figs. 1-6; Panning 1928a, p. 223.

Holothuria nitida Ives 1891, p. 322, Pl. 8, figs. 10-15; Panning 1928a, p. 223.

Holothuria silamensis Ives 1891, p. 320, Pl. 8, figs. 7-9.

Body subcylindrical, slightly tapers at both ends. Medium size; average size measuring 100 mm. long x 25 mm. diam. Mouth slightly ventral with 20 small peltate tentacles. Anus terminal. Pedicels numerous at ventral side and few on dorsal side intermixed with the papillae which are surmounted on conical warts. Color in preserved state variable from homogenous light yellow or grayish to irregularly spotted with dark purplish blotches.

Deposits:

Few tables and numerous rosettes. Table with small disk, a central hole and 4 small marginal ones, although a few with as many as 12 holes. Spire composed of 4 pillars which terminate distally in a spinous crown with 12 spines. Rosettes small of various forms from simple dichotomous X-shaped to regular plate-like with larger holes. Pedicels with regular end-plate and few huge button-like plates. Tip of papillae with rudimentary end plate and numerous supporting rods.

Specimens examined:

Acc. No.—Locality	*Individual No.*
AHF-Al-39: Florida	4
AHF-LM13-49: "	4
AHF-LM15-49: "	12
AHF-LM21-49: "	11
AHF-LM27-49: "	1
AHF-A50-39: "	18

HOLOTHURIA GLABERRIMA Selenka

Holothuria glaberrima Selenka 1867, p. 328, Pl. 18, figs. 57, 58; Semper 1868, pp. 92, 279; Lampert 1885, p. 90; 1896, pp. 56-59, fig. la; Theel 1886a, p. 205; Sluiter 1895, p. 78; 1910, p. 333; Ludwig 1898 a, p. 434; Clark, H.L.

1902a, p. 258; Koehler and Vaney 1903, p. 8, Pl. 1, fig. 6; Pearson 1913, p. 62, Pl. 8, fig. 8; Deichmann 1926, p. 17; 1930, p. 69, Pl. 4, figs. 10-13.

Holothuria erinaceus Semper 1868, pp. 91, 250, 279, Pl. 30, fig. 24, Pl. 34, fig. 9, Pl. 35, fig. 14, Pl. 36, fig. 11. Pl. 38, figs. 1 & 2; Lampert 1885, p. 90; 1896, pp. 56-59, fig. Ib; Theel 1886a, p. 206; Sluiter 1887, p. 186; 1895, p. 78; Ludwig 1898a, 434; Stephenson T.A. et al 1931, p. 59; Clark, H.L. 1932, p. 232.

Holothuria erinaceus Semper var. pygmae Semper 1868, p. 91, Pl. 30, figs. 23-24; Lampert 1885; p. 90; Theel 1886a, p. 206.

Holothuria lubrica Selenka var. *glaberrima* Mitsukuri 1912, p. 96.

Body cylindrical, tapers slightly at both ends. Medium size, average measurement 80 mm. long x 20 mm. diam. Mouth slightly ventral, almost terminal with 20 small peltate tentacles. Anus terminal. Pedicels scattered all over the body, crowded in 3 indistinct bands on the ventrum, sparse and irregularly arranged on dorsum. Color in preserved state dark brown. Integument soft and somewhat smooth.

Deposits :

Numerous straight to curved rods with branched or spinous ends, few with a mid-lateral branch and others appear like a triradiate rods recemous at both ends. Pedicel with large regular end-plate but without supporting rods.

Specimens examined :

Acc. No.—Locality	*Individual No.*
AHF-A50-39: Florida	4

HOLOTHURIA GRISEA Selenka

Holothuria grisea Selenka 1867, p. 328, Pl. 18, figs. 52-56; Semper 1868, pp. 92, 251; Greef 1882, p. 118; Ludwig 1882, p. 26; Lampert 1885,p. 85; Theel 1886, p. 214; Clark, H.L. 1901b, p. 258; 1919, p. 63; Deichmann 1926, p. 15; 1930, pp. 76-77, Pl. 5 figs. 1-4.

Body subcylindrical. Small size, average measurement 30 mm. long x 10 mm. diam. Mouth ventral and anus terminal. Tentacles partly retracted but apparently 20 peltate forms. Pedicels on the ventral side arranged in somewhat three bands, and papillae in 2 doubled indistinct series on the dorsal side surmounted on warts. Color in preserved state uniformly purplish gray.

Deposits:

Tables few, with small disk, usually with a central hole and marginal ones from 4 to 12. Spire composed of 4 pillars with 2 cross-beams and terminate distally into a spinous crown with 12 short spines. With regular-shaped small plates with two or four mid-holes and terminal smaller ones. Few irregular-shaped or variable forms. Pedicels with regular end-plates and curve supporting rods dilated and perforated at both ends

Specimens examined:

Acc. No.—Locality	*Individual No.*
AHF-A56-39: Florida	2
AHF-A50-39: "	1

HOLOTHURIA IMPATIENS (Forskal)

Fistularia impatiens Forskal 1775, pp. 121-129, Pl. 39, fig. B.

Holothuria aphanes Lampert 1885, p. 242; Ostergren 1898, p. 233; Sluiter 1901, p. 16.

Holothuria fulva Quoy & Gaimard 1833, p. 135.

Holothuria botellus Selenka 1867, p. 335, Pl. 19, figs. 82-84; 1868, p. 117; Semper 1868, pp. 82, 248; Saville-Kent 1893, pp. 234, 238.

Holothuria impatiens Seleaka 1867, p. 340; Semper 1868, pp. 82, 277; 1869 p. 120; Gray 1872, p. 123; v. Marenzeller 1874, p. 320; Ludwig 1879, p. 569; 1880, p. 6; 1882, p. 136; 1883, p. 169; 1887c, p. 31; 1887d, p. 1226; 1888, p. 806; 1889-92, p. 329; 1899, p. 558; Haacke 1880; p. 46; Bell 1884c, p. 510; 1887a, pl. 140; 1887c, p. 654; 1888, p. 389; Lampert 1885, p. 65; 1889, p. 812; 1896, p. 54; 1889, p. 312; Theel 1886, p. 7; Sluiter 1887, p. 47; 1895, p. 78; 1901, p. 9; Herourd 1889, p. 677; 1893, p. 134; Saville-Kent 1893, pp. 233, 237; Koehler 1895b, p. 282; 1895c, p. 12, fig. 11; 1921, p. 173, fig. 129; 1927, p. 214, Pl. 16, fig. 19; Bordas 1893, p. 840; 1889a, pp. 187-204; 1899, p. 16, Pl. 1; Bedford 1898, p. 840; 1899, p. 145; Ostergren 1898, pp. 233-237; Risso 1899, pp. 133-141; 1900, pp. 38-41; Clark, H. L. 1902,a p. 258; 1902 b, p. 528; 1920, p. 149; 1921, p. 178, fig. 2; 1923, p. 423; 1925, p. 103; 1926, p. 192; 1932, p. 232; Konningsberger 1904, p. 51, Pl. 8, fig. 3; Fisher 1907, p. 660, Pl. 69, fig. 4; Koehler and Vaney 1908, p. 8; Pearson 1910 a, p. 178; 1910b, p. 192; 1913, p. 85, Pl. 13, fig. 21; 1914, p. 171; Misukuri 1912, p. 80, text-fig. 17; Erwe 1913, p. 369; Mortensen 1926, p. 117; Deichmann 1926, fig. 11; 1930, p. 64, Pl. 3, figs. 17-18; Schmidt 1929, pp. 1365, 1391, figs. 197-198; 1930 pp. 406-412; 419-424, 459, 483, figs. 36-43, 52, 53, 64, 75, 85, 98; Stephenson, T.A. et al 1931, p. 55; Domantay 1933, p. 66, Pl. 2, fig. 4; 1953a, pp. 110, 114-115; 1953b, pp. 135, 1954, pp. 337, 344-346. Panning 1935, pp: 86-88, text-fig. 72.

Body cylindrical, medium size. Mouth and anus terminal. Pedicels scattered all over the body and distinctly papillated, the conical tips surmounted on warts. Integument rough and tough. Color in preserved state dark brown mottled with tiny spots with two rows of dark purplish blotches on dorsal side.

Deposits:

Numerous buttons and tables. Tables large with squarely disk and large holes. Spire somewhat massive with a cross-beam and with spinous crown. Buttons smooth and regular in shape, usually with 3 pairs of holes. Pedicels with regular end-plate and supporting rods typical to the species dilated and perforated at the middle and with terminal small perforations.

Specimens examined:

Acc. No.—Locality	*Individual No.*
AHF-A8-39: Florida	1

HOLOTHURIA MEXICANA Ludwig

Holothuria mexicana Ludwig 1875, p. 25, Pl. 7, fig. 47; Lampert 1885, p. 85; Theel 1886a, p. 215; Herouard 1902, p. 7, Pl. 1, fig. 16; Sluiter 1910, p. 333; Deichmann 1926, p. 16; 1930, p. 74, Pl. 5, figs. 15-20.

Holothuria africana Theel 1886a, p. 174, Pl. 8, fig. 7; Clark, H. L. 1923, p. 422; Schmidt 1925, p. 134.

Holothuria floridana Clark, H. L. 1898, p. 413, 1919, p. 63; Edwards 1905, p. 383; 1907, p. 211, 1908a, pp. 538-539; 1908b, p. 236, Pls. 1-5; 1909; pp. 211-230; Sluiter 1910, p. 333; Clark, H. L. 1919, p. 63; Panning 1928a, p. 220.

Body subcylindrical, medium size, measuring 110 mm. long x 30 mm. diam. Mouth slightly ventral and anus terminal. Peltate tentacles partly retracted, apparently 20. Pedicels scattered all over body and partly retracted, somewhat papillated on dorsal side. Few regular papillae surmounted on low warts. Color in preserved state purplish brown on dorsal side and yellowish on ventral, appearing spotted when the pedicels are all retracted with nothing exposed but the tips.

Deposits:

Few tables with small disk with 4 small marginal holes, spire with 2 cross-beams terminating in spinous crown with 4 vertical and 8 horizontal spines or teeth. Tables resemble those of *H. floridana* Pourtales. Numerous small button-like plates of two general types, one with 4 holes (2 lateral elongated and 2 terminal roundish ones), the other type is biscuit-shaped with numerous small holes. Between these two general types are intermediate forms. Pedicels with regular end-plate, the papillae with rudimentary one. Supporting rods curve with bifurcated ends.

Specimens examined:

Acc. No.—Locality	*Individual No.*
AHF-A56-39: Florida	1

HOLOTHURIA SURINAMENSIS ludwig

Holothuria surinamensis Ludwig 1875, p. 35, fig. 27; Deichmann 1926, p. 12, Pl. 1 figs. 1, 1a-g, 2a-b; 1930, pp. 63-64, Pl. 3, figs. 12, 15, 19.

Holothuria languens Semper (partim) pp. 87, 248.

Holothuria subditiva Selenka 1867, p. 338, Pl. 19, fig. 87 (partim).

Body cylindrical, tapers at both ends, medium size, measuring 110 mm. long x 25 mm. diam. Mouth and anus terminal; 20 small pelltate tentacles. Pedicels scattered all over body but more prominent and crowded on the ventrum with dirty white tips, less conspicuous and partly retracted on dorsum. Integument tough, rough and wrinkled due apparently to contraction. Color in preserved state purplish brown, slightly lighter on ventrum.

Deposits:

Numerous tables without disk, spire composed of 4 pillars, with 2 cross-beams terminating in a spinous crown with from 8 to 12 teeth. In some tables 1 or 2 teeth may be found in one of the pillars below the crown. Long flattened rods with dentate margins, some devoid of dentations at the middle. Pedicels with end-plate and numerous supporting rods of the type described above.

Specimens examined:

Acc No. —Locality	*Individual No.*
AHF-A8-39: Florida	1

HOLOTHURIA TUBULOSA Gmelin

Holothuria tubulosa Gmelin 1867; Cuvier 1821, p. 316; 1830, p. 174; 1816-1830, p. 19, Pl. 10, figs. 1-4: Selenka 1867, p. 323, Pl. 18, figs. 42-43; Panning 1935, pp. 77-78, text-fig. 60; v. Merenzeller 1874, p. 314; Lampert 1885, p. 76; Theel 1886a, p. 225; Koehler 1893, p. 366, fig. 16; 1894b, p. 423; 1921, p. 174, fig. 130; 1927, p. 215, Pl. 16, fig. 25; Herouard 1896, p. 164; 1923, p. 9; 1929, p. 48; Clark, H.L. 1925, pp. 102-104; Schmidt 1929, p. 1365; 1930, pp. 406, 407, 411-415, 424, 428-431, 454, 466, 488, figs. 44, 45, 46, 47, 56-58.

Holothuria columnae delle Chiaje 1823.
Holothuria maxima delle Chiaje 1823.
Holothuria pentagnae delle Chiaje 1823.

Body cylindrical, medium size, measuring 120 mm. x 20 mm. diam. Mouth ventral and anus terminal. 20 small peltate tentacles. Outer rim of anus with several bifurcated papillae. Pedicels scattered all over the body, bigger and crowded on the ventrum without any regular arrangement. With lateral series of warty protuberances surmounted with papillae, smaller pedicels scattered on the dorsum. Integument hardy and apparently thick. Color in preserved state brown on dorsum and yellowish on ventrum due to numerous yellowish tips of the pedicels.

Deposits:

Tables and buttons. Tables with irregular spinous disk with 4 central holes and from 4 to 14 smaller marginal ones. Spire composed of 4 pillars, 2 cross-beams and terminate in spinous crown with 12 moderate spines. Buttons spinous with 3 pairs of holes. The only species so far encountered with spinous buttons by the writer. Pedicels with regular endplate and supporting rods varying from spinous rods to spinous huge buttonlike plates.

Specimens examined:

Acc. No.—Locality	*Individual No.*
AHF-A30-39: Florida	1

Genus ACTINOPYGA Bronn

ACTINOPYGA AGASSIZI (Selenka)

Mulleria agassizi Selenka 1867, p. 311, Pl. 17, figs. 10-12; Theel 1886, p. 202; Lampert 1885, p. 98; Edwards 1891, p. 75; Clark, H.L. 1901a, p. 494.

Actinopyga agassizi Verrill 1867-81, p. 347; Sluiter 1910, p. 333; Pearson 1914a, p. 169; Crozier 1917, p. 405; Deichmann 1930, p. 78, Pl. 5, figs. 21-29.

Holothuria (*Actinopyga*) agassizi Panning 1931, p. 126. text-fig. 7.

Body robust, sub-cylindrical, partly contracted measuring 150 mm. long x 40 mm. diam. Mouth ventral and anus terminal. With 27 peltate tentacles. Anus with 5 calcareous teeth. Pedicels crowded on ventrum and papillae on dorsum some of which are surmounted on warty conical protuberances. Integument thick and tough. Color in preserved state variable from almost uniform brown to mottled purplish brown, with irregular blotches of purple on the dorsum.

Deposits:

Numerous small short rods and rosettes, the latter ranges from bifurcated X-rods to fully formed rosettes. With few bigger cross-shaped bodies, racemose and perforated at distal ends. Pedicels with regular end-plate, cross-shaped bodies and double-wrench-shaped supporting rods.

Specimens examined:

Acc. No.—Locality	*Individual No.*
AHF-A56-39: Florida	4

Genus STICHOPUS Brandt 1835

STICHOPUS BADIONATUS Selenka

Stichopus haytiensis Semper 1868, p. 75, Pl. 30, fig. 5.

Stichopus mobi Semper 1868, p. 246, Pl. 40, fig. 11.
Stichopus errans Ludwig 1875, p. 97.
Stichopus maculatus Greef 1882, p. 158; Sluiter 1910, p. 333.
Stichopus assimilis Bell 1883, p. 62.
Stichopus diaboli Heilprin 1888, p. 312.
Stichopus xanthomela Heilprin 1888, p. 313.
Stichopus acanthomela Zool. Rec. 1900, p. 78 (err. typ.)

Stichopus badionatus Selenka 1867, p. 316, Pl. 18, fig. 26; Clark, H.L. 1922, p. 55; Deichmann 1930, p. 80, Pl. 5, figs. 30-36.

Young specimen measuring 30 mm. long x 12 mm. wide x 6 mm. thick, Rather in bad shape. Tentacles retracted and pedicels apparently gone with the integument from the ventrum. What are conspicuous are the warty protuberances with the retracted papillae on the dorsum. Integument soft and partly disintegrated on the ventrum. Color in the preserved state brownish.

Deposits:

Mostly tables of various sizes. Small tables with small disk and low spire; big ones with bigger disk and taller spire. Disk with 4 large central holes and 12 peripheral ones, 4 of which are bigger than the other eight; the 12 marginal ones almost the same in size in some tables. Spire vary in height, the lower ones with 2 cross-beams and the taller with 3. Spire terminates distally in a spinous tuft or crown. Spicules of the young individual differ a great deal from that of the adult.

Specimens examined:

Acc. No.—Locality	*Individual No.*
AHF-A14-39: Florida	1

Order DENDROCHIROTA Grube
Family PHYLLOPHORIDAE
Genus PHYLLOPHORUS Grube 1840

PHYLLOPHORUS (URODEMELLA) OCCIDENTALIS Ludwig

Thyonidium occidentalis Ludwig 1885, p. 119, Lampert, 1885, p. 70, Theel, 1886 p. 147.

Thyone constituta Sluiter 1910, p. 340, text-fig. E; Deichmann 1926, p. 24.

Phyllophorus occidentalis Deichmann 1930, pp. 148-149, Pl. 18, figs. 1-2; Clark, 1933, p. 112.

Phyllophorus (*Urodemella*) *occidentalis* Heding and Panning 1954, pp. 164-165, text fig. 76.

Body barrel-shaped, tapering at both ends, small size, measuring 50 mm. long x 20 mm. diam. at middle. Tentacles retracted, mouth terminal. Anal end slightly turned dorsad. Pedicels scattered all over body but those along the radii or ambulacra are in serial arrangement. Integument soft and somewhat thin. Color in preserved state uniformly brown but darker on the dorsum.

Deposits:

Tables only with well developed disk and scalloped margin and reduced spire. The pillars of the spire apparently fused and slightly raised terminating in a narrow rectangular top with acute angles. In some, the terminal top of the spire does not show any angle. Pedicels with well developed end-plate and few irregular spectacle-shaped rods around the margin.

Specimens examined:

Acc. No.—Locality	*Individual No.*
AHF-A25-39: Florida	1

EUTHYONIDIELLA ZACAE (Deichmann)

Phyllophorus zacae Deichmann 1938, p. 381, Text fig. 13, 15; 1941, pp. 134-135, Pl. 24, figs. 12-21.

Euthjonidiella zacae Heding and Panning 1954, pp. 118-119, text fig. 48.

Body elongated and partly twisted in three different regions. Small size, measuring 30 mm. long x 5 mm. diam. Body tapered at both ends, mouth and anus terminal. Pedicels scattered all over. Tentacles retracted. Color in preserved state dirty white.

Deposits:

Delicate tables with oval disk perforated with 8 symmetrical holes typical to the species. Spire with 2 to 4 pillars, mostly 2 with a single cross-beam terminating in 4 tufts of spines. Pedicel's with regular end-plate and supporting tables with oblong perforated curve disk and spire with 2 pillars and a cross-beam, terminating in 2 prominent diverging spines or horns, or in a single point exactly as illustrated in Deichmann 1941, Pl. 24, figs. 12-21.

Specimens examined:

Acc. No.—Locality	*Individual No.*
AHF-A14-39: Florida	2

Family CUCUMARIIDAE

Genus NEOTHYONE Deichmann 1941

NEOTHYONE CAPENSIS (Theel) var. TROJANI Domantay

Neothyone capensis (Theel) var. *trojani* Domantay 1953 (a) Phil. Jour. sci. vol. 82, no. 2

Small size, measuring 10 mm. long x 3 mm. diam. Body slightly tapers at both ends, smaller at the anal end. Mouth and anus terminal, and slightly turned upward. Tentacles slightly retracted, apparently 10 bushy with 2 small ventral ones. Actually counted 8 large ones. Pedicels prominent and distinctly in double series on the ventro-lateral ambulacra, and zigzaggy arrangement on the dorsal ambulacra. Integument leathery and tough due to calcareous deposits. Color in preserved state brownish, much lighter on the ventrum.

Deposits:

Numerous highly knobbed buttons with four holes, the 2 laterals bigger and elongated than the terminals, and wirh 8 prominent marginal knobs and 2 central ones. Mostly symmetrical although in some, extra small holes modify the perfect symmetry. Few large perforated and knobbed plates with from 9 to 12 round holes. Delicate 4-holed baskets with spinous margin usually with 12 or more teeth. Delicate rods, majority are triaxon resembling those of a sponge spicule. Pedicels with rudimentary end-plate surrounded by few perforated plates of uniform shape. Supporting perforated rods modified into elongated perforated plates.

Specimen examined	—	*Individual No.*
Acc. No. Loality AHF-A25-39 Florida	—	1

Genus LEPTOPENTACTA H.L. Clark, 1938

LEPTOPENTACTA DEICHMANNAE Domantay 1953

Leptopentacta deichmanae Domantay, 1953 (a) Phli. Jour. sci. vol. 82, no. 2

Body pentagonal with both ends directed dorsad giving a semi-lunar shape. Mouth and anus terminal. Tentacles retracted. Along each ambulacral areas are single series of prominent conical appendages apparently representing the pedicels. Integument stiff with large cobblestone-like scales. General external appearance is identical with *L. nova* Deichmann, the difference is in the conical appendages which are more numerous and sharply pointed in the new species. The sharp conical appendages extend to both ends reduced in size and somewhat crowded unlike in *L. nova* Deichmann. External appearance resembles *Ocnus typicus* Theel, Pl. 14, fig. 11, and *Ocnus imbricatus* Semper, Pl. 11, fig. 2.

Deposits:

Large reticulated scale-like plates, numerous perforated disc-shaped plates of various sizes, mostly with smooth margins and small delicate flask-shaped baskets. The delicate flask-shaped baskets which are liable to be overlooked in the examination of the spicules is the characteristic difference from the other known species of *Leptopentacta*.

Specimens examined :

Acc. No.	—	*Locality*	*Individual No.*
AHF—A4-39		Florida	1
AHF—AL-39		,,	4

LEPTOPENTACTA NOVA Deichmann var. FLORIDANA
Domantay

Leptopentacta nova Deichmann var. *floridana* Domantay 1953 (a), Phil. Jour. sci. vol. 82, no. 2.

Body slender, crescent-shaped with rigid body wall. Small size, the biggest measures 20 mm. long x 2.5 mm. diam. Pedicels apparently contracted into conical protuberances ranging from 15 to 20 in single series along each ambulacrum. Integument with large cobblestone-like scales. Tentacles very small and partly retracted. Mouth and anus terminal. Color in preserved state light brown to dark brown all over but lighter at both ends and at the conical appendages. Externally resembles *L. nova* Deichmann with minor differences. The cobblestone-like scales not very conspicuous, conical appendages smaller and more numerous than in the straight species.

Deposits:

Large reticulated scales and numerous button-like plates, rather irregular in shape although majority are oval and somewhat knobbed with 4 holes or more. All these resemble those of *L. nova* Deichmann. The difference is the absence of the minute perforated biscuit-shaped plates, but in their place are somewhat delicate irregular perforated plates resembling shallow baskets.

Occ. no.—Locality	*Individual no.*
AHF-A7-39	(2)
AHF-A53-39	(9)
AHF-A4-39	(2)
Florida	

LEPTOPENTACTA NOVA Deichmann var. GEMMATA
Domantay

Leptopentacta nova Deichman var. *gemmata*, Domantay, 1953 (a), Phil. jour. sci. vol. F2, no. 2.

Body U-shaped with both ends blunt measuring 10 mm. long x 2 mm. diam. Small size form. Tentacles retracted. Pedicels surmounted on low conical appendages arranged in single series along each ambulacrum. Integument with cobblestone-like scales. Color in preserved state almost white. External appearance very close to *L. nova* Deichmann with regard to the distance and height of the conical appendages but the cobblestone-like scales much smaller. Both ends are blunt unlike in the straight species. Mouth and anus terminal.

Deposits:

Large reticulated scales and numerous 4-holed buttons of distinctive characteristic form resembling a modified lozenge shape with from 8 to 12 marginal protuberances, some smooth and others knobbed. In the place of the biscuit-shaped plates found in the straight species are baskets with from 4 to 8 holes and from 8 to 12 marginal teeth. In addition are large perforated plates of irregular shape. Pedicels with few supporting perforated plates ranging from spectacle-shaped to regular curved plates. Apparently with no end-plate.

Specimens examined :—

Acc. No.—Locality	*Individual No.*
AHF-A32-39 Florida	(1)

Genus LUDWIGIA Panning

LUDWIGIA AMERICANA Domantay

Ludwigia Americana Domantay, 1953 (a) Phil. Jour. sci. vol. 82, no. 2.

Body somewhat quadrangular due apparently to state of preservation, slightly tapering at both ends. Small size, measuring 30 mm. long x 7 mm. diam. Mouth and anus terminal with small calcareous papillae, 10 equal bushy tentacles. Pedicels scattered all over the body without regular arrangement although some may be in indistinct series. Integument stiff and rough due to numerous deposits.

Deposits:

Large mulberry-shaped bodies and numerous 40-holed highly knobbed buttons appearing like cluster of beads and spinous baskets. Tentacles with slightly curved somewhat irregular rods slightly racemose or perforated at both ends.

Specimens examined

Acc. No.—Locality	*Individual No.*
AHF-A15-39 Florida	(1)

Genus THYONE Oken 1815

THYONE CLARKI Domantay

Thyone clarki Domantay, 1953 (a), Phil. Jour. sci. vol. 82, no. 2.

Body ascidian-shaped, mouth and anus terminal directed upward, the latter much slender. Small size. Tentacles retracted, pedicels in two series along each ambulacrum and apparently non-retractile. Integument thin and hardy due to numerous tiny deposits in the form of tables. Color in preserved state dirty white all over.

Deposits:

Numerous tiny tables with slightly irregular perforated disk, the holes ranging from 4 to 20 up, the average number is 9. Spire solid and robust terminating into finely spinous top, some with 3 spinous knobs.

Specimen examined

acc. no.—Locality	*Individual no.*
AHF-A14-39 Florida	(1)

THYONE FLORIDANA Domantay

Thyone Floridana Domantay 1953 (a) Phil. Jour. sci. vol. 82, no. 2.

Body robust, cylindrical and slightly bent with both mouth and anus terminal. Small size, measuring 5 mm long x 3 mm. diam. Tentacles retracted. Pedicels arranged in single series along each ambulacrum. Integument thin and hardy. Color in preserved state dirty white.

Deposits:

Numerous perforated plates from elongated to circular forms. Smaller tables about 1/4 the size of the plates with circular perforated disk and massive cylindrical spire, apparently fusion of the pillars. The solid cylindrical spire terminates in tetra-spinous top in some although in majority the terminal tip is bare. Pedicels without end-plate and with small spectacle-shaped supporting rods.

Specimens examined:

acc. no.—Locality	*Individual no.*
AHF-A14-39 Florida	(1)
AHF-A-32-39 Florida	(1)

THYONE FUSUS (O.F. Muller)

Body robust crescent-shaped, attenuated at both ends. Mouth and anus terminal. Tentacles partly retracted. Non-rectractile pedicels in double series along each ambulacrum and rather irregular in the interambulacral region. Integument rough and hardy due to deposits. Color in preserved state light yellow.

Deposits:

Numerous 4-holed tables with oval or lozenge-shaped disk, spire composed of two rods converging into a cone, some with tiny spines at tip.

Disk of few tables with more than 4 holes and irregular in shape. Pedicels with rudimentary end-plate and numerous small supporting tables, some with reduced spire appearing like spectacle in shape.

Specimens examined:

Acc. No.—Locality	*Individual No.*
AHF-A43-39: Florida	1

THYONE PERVICAX Theel

Thyone pervicax Theel 1886a, p. 93, Pl. 5, fig. 9;

Deichmann 1930, pp. 175-176, Pl. 16, figs. 9-12.

Body cylindrical, slightly curved and tapers at both ends. Measures 40 mm. long x 6 mm. dima. at middle. Tentacles retracted and oral opening pentagonal with 5 radial calcareous lips. Mouth and anus terminal. Pedicels somewhat conical arranged in indistinct bands along the ambulacral area. Integument stiff, loaded with deposits. Color in preserved state brownish.

Deposits:

Numerous 4-holed knobbed buttons of different sizes and cups, and few large rounded mulberry-shaped bodies. Pedicels without end-plate but with curved supporting rods of different forms, some elongated and perforated plate-like, others dilated and perforated at one end and slender pointed at the other end.

Specimens examined;

Acc. No.—Locality	*Individual No.*
AHF-AL-39: Florida	1

THYONE PSEUDOFUSUS Deichmann

Thyone pseudofusus Deichmann 1930, pp. 168-169, Pl. 14, figs. 6-9.

Body slightly bent with both mouth and anus upward and terminal. Small size, measuring 8 mm. long x 3 mm. diam. Pedicels in double rows along each ambulacrum and also scattered in the interambulacra. The specimen partly contracted seem to show that the pedicels are scattered all over the body. Tentacles retracted. Color in preserved state brownish on dorsum and lighter on ventrum.

Deposits:

Tables with button-like 4-holed disk with smooth to slightly knobbed margin. Spire robust, low composed of 2 pillars with distinct teeth at top.

Many with handle opposite the spire. Pedicels with regular end-plate and numerous elongated lozenge-shaped supporting tables with small spire of two rods.

Specimens examined:

Acc. No.—Locality	*Individual No.*
AHF-A-12-39: Florida	1

THYONE TENELLA Selenka

Thyone tenella Selenka 1867, p. 354, Pl. 20, figs. 113-114.

Body barrel-shaped with both ends conical. Small robust form, measuring 30 mm. long x 20 mm. diam. Mouth and anus terminal. Tentacles partly retracted. Anus with 5 calcareous teeth. Fedicels scattered all over the body with distinct double series along each ambulacrum. Integument thin, soft but hardy.

Deposits:

No integumentary deposits except the numerous supporting tables of the pedicels. Curved, elongated disk dilated at the middle with 4 holes, both ends slightly dilated and perforated. Spire composed of 2 pillars and 2 cross-beams terminating in a spinous top. End-plate well developed and reinforced with few elongated perforated plates around the margin.

Specimens examined:

Acc. No.—Locality	*Individual No.*
AHF-A59-39: Florida	1

Order APODA Brandt

Family SYNAPTIDAE Ostergren

Genus EUAPTA Ostergren 1898

EUAPTA GODEFFROYI (Semper)

Synapta godeffroyi Semper 1868, p. 231, Pl. 39, fig. 13.

Euapta godeffroyi Ostergren 1898, p. 113; Clark, H.L. 1907, pp. 72-73; 1924, pp. 462-464, Pl. 1. figs. 1-4; Fisher 1907, pp. 721-722, Pl. 81, fig. 3 a-c; Domantay 1933, p. 85, Pl. 2, fig. 9; 1953a, pp. 134-140, 1954, pp. 338, 353.

Medium size, measuring 200 mm. long x 10 mm. diam. Body cylindrical tapering posteriorly. Mouth and anus terminal. 14-15 Pinnate tentacles. Integument thin and sticky. Anchors stick out from the integument making the skin sticky to the touch. Color in preserved state greenish brown and variegated with irregular white specks. The five longitudinal bands partly visible contributing to its external appearances.

Deposits:

Anchors, anchor-plates and numerous miliary granules. Stock of anchor with 8 spinous processes; arms smooth. Anchor-plate bilaterally symmetrical with 7 dentate holes (1 central and 6 peripheral ones). Handle of plate with 2 bigger holes and 3 smaller ones. Miliary granules resembling a group of granules packed together into a circular disk with small central hole.

Specimens examined:

Acc. No.—Locality		*Individual No.*
AHF-A50-39:	Florida	1
AHF-A59-39:	"	5

Genus POLYPLECTANA H.L. Clark 1904.

POLYPLECTANA KEFERSTEINII (Selenka)

Synapta kefersteinii Selenka 1867, p. 360, Pl. 20, figs. 120-121 Semper 1868, p. 14, Pl. 5, fig. 24, Pl. 39, fig. 11.

Synaptula kefersteinii Fisher, 1907.

Polyplectana kefersteinii Clark, H. L. 1908, pp. 16, 77, Pl. 4, figs. 20-22; 1904, pp. 468-471, Pl. 1, figs. 8-12; Domantay 1933, p. 88, Pl. 2, fig. 8.

Body cylindrical, small size, measuring 42 mm. long x 4 mm. diam. Mouth and anus terminal. 12 small pinnate tentacles. Integument transparent. Color in preserved state brownish green speckled with numerous tiny white spots representing the location of the anchor and anchor-plate spicules.

Deposits:

Numerous anchor and anchor-plates. Stock of anchor without distinct processes but with very minute spines. Anchor arms smooth with few granuliform teeth or protuberances on vertex. Anchor-plate symmetrical, with one central and six large peripheral dentate holes, one of which is an inverted heart-shaped, smaller and partially dentated. Handle with two large and two or more small perforations. Bow of handle partially dentated on posterior border. Miliary granules irregular in shape and size, mostly oval. Several grouped together forming a rosette.

Specimens examined:

Acc. No.—Locality		*Individual No.*
AHF-A59-39:	Florida	1

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ON THE CHARACTERISTIC FUNCTION OF A MEROMORPHIC FUNCTION.

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1. Let $T(r, w) = T(r)$ denote the characteristic function in the Spherical Normal form [1, p. 176] of a meromorphic function $w(z)$. By a well known theorem of Shimizu and Ahlfors (see e.g. [1] p. 177)

$$(1.1) \qquad T(r) = \int_0^r \frac{A(t)}{t}\,dt,$$

where

$$A(r) = \frac{1}{\pi} \int_0^r \int_0^{2\pi} \left(\frac{\left| w'\left(te^{i\theta}\right) \right|}{1 + \left| w\left(te^{i\theta}\right) \right|^2} \right)^2 t.\,dt.\,d\theta.$$

In usual notations let

$$\rho = \overline{\lim_{r\to\infty}} \frac{\log T(r)}{\log r}$$

and

$$\lambda = \underline{\lim_{r\to\infty}} \frac{\log T(r)}{\log r}$$

denote respectively, the upper order and the lower order of a meromorphic function.

It is easy to show by usual technique that

$$(1.2) \qquad \begin{matrix}\rho \\ \lambda\end{matrix} = \lim_{r\to\infty} \begin{Bmatrix}\text{Sup.} \\ \text{Inf.}\end{Bmatrix} \frac{\log A(r)}{\log r}$$

As a matter of fact from (1.1) it follows that

$$T(r) = K(r_0) + \int_{r_0}^r \frac{A(t)}{t}\,dt < K(r_0) + A(r) \log r$$

and so

$$(1.3) \qquad \begin{matrix}\rho \\ \lambda\end{matrix} = \lim_{r\to\infty} \begin{Bmatrix}\text{Sup.} \\ \text{Inf.}\end{Bmatrix} \frac{\log T(r)}{\log r} \leq \lim_{r\to\infty} \begin{Bmatrix}\text{Sup} \\ \text{Inf.}\end{Bmatrix} \frac{\log A(r)}{\log r}$$

On the other hand

$$T(2r) \geqslant \int_r^{2r} \frac{A(t)}{t}\,dt \geqslant A(r) \log 2$$

or

$$\frac{\log T(2r)}{\log 2r} \geqslant \frac{\log A(r)}{\log r} \cdot \frac{\log r}{\log 2r} + \frac{\log \log 2}{\log 2r}$$

and hence

$$\text{(1.4)} \qquad \begin{matrix}\rho\\ \lambda\end{matrix} = \lim_{r\to\infty} \begin{Bmatrix}\text{Sup}\\ \text{Inf.}\end{Bmatrix} \frac{\log T\ (2r)}{\log 2r} \geqslant \lim_{r\to\infty} \begin{Bmatrix}\text{Sup}\\ \text{Inf.}\end{Bmatrix} \frac{\log A\ (r)}{\log r}$$

and these two inequalities (1.3) and (1.4) embody the result (1.2)

2. The object of this paper is to investigate certain relations between $A\ (r)$, λ, P, $T\ (r)$ and its derivative $T'\ (r)$. Our main results read as follows :—

Theorem. A. If $o<r_1<r_2$, then

$$\text{(2.1)} \quad \left(\frac{r_2}{r_1}\right)^{A\ (r_1)} \leqslant \frac{\exp\ T\ (r_2)}{\exp\ T\ (r_1)} \leqslant \left(\frac{r_2}{r_1}\right)^{A\ (r_2)}$$

(exp x means e^x)

Proof : We have by the Shimizu—Ahlfors identity (1.1)

$$\begin{aligned} T\ (r_2) &= T\ (r_1) + \int_{r_1}^{r_2} \frac{A\ (t)}{t}\, dt \\ &\leq T\ (r_1) + A\ (r_2) \log \frac{r_2}{r_1} \\ &\geqslant T\ (r_1) + A\ (r_1) \log \frac{r_2}{r_1} \end{aligned}$$

Hence

$$A\ (r_1) \log \frac{r_2}{r_1} \leqslant T\ (r_2) - T\ (r_1) \leq A\ (r_2) \log \frac{r_2}{r_1}$$

which gives the result.

Cor. 1. If α be any constant greater than unity, then

$$\alpha^{A\ (r)} \leqslant \frac{\exp\ T\ (\alpha r)}{\exp\ T\ (r)} \leq \alpha^{A(\alpha r)}$$

It follows from (2.1) by putting $r_1 = r$, and $r_2 = \alpha r$.

3. We next prove a result depending on the convexity property of the characteristic function T (r).

Theorem. B.

$$\text{(3.1)} \qquad T\left(\mathop{\pi}_{i=1}^{n} r_i^{\,p_i}\right) \leq \sum_{i=1}^{n} p_i\, T\ (r_i)$$

where p_i's are rational positive numbers such that $\sum_{i=1}^{n} p_i = 1$

Proof:

It is well known that T (r) is a convex function of log r. We draw the. the graph of T (r) and take n points p_1, p_2, ...p_n on it with coordinates :

$$\begin{aligned} p_1 &: \ (\log r_1, \mathrm{T}(r_1)) \\ p_2 &: \ (\log r_2, \mathrm{T}(r_2)) \\ &\dots\dots\dots\dots\dots \\ &\dots\dots\dots\dots\dots \\ p_n &: \ (\log r_n, \mathrm{T}(r_n)) \end{aligned}$$

The coordinates of the point Q_1 which divides tte chord $P_1 P_2$ in the ratio $m_2 : m_1$ are :

$$\left(\frac{m_1 \log r_1 + m_2 \log r_2}{m_1+m_2}, \ \frac{m_1 \mathrm{T}(r_1) + m_2 \mathrm{T}(r_2)}{m_1+m_2} \right)$$

Next join Q_1 and P_3. The coordinates of the point Q_2 dividing the line Q_1P_3 in the ratio $m_3 : m_1+m_2$, are

$$\left(\frac{m_1 \log r_1 + m_2 \log r_2 + m_3 \log r_3}{m_1+m_2+m_3}, \ \frac{m_1 \mathrm{T}(r_1) + m_2 \mathrm{T}(r_2) + m_3 \mathrm{T}(r_3)}{m_1+m_2+m_3} \right)$$

Again join Q_2 and P_4 and determine the coordinates of the next point Q_3 dividing the line $Q_2 P_4$ in the ratio $m_4 : m_1+m_2+m_3$. Thus go on repeating the process until all the points P_n are exhausted. Lastly we get the point Q_{n-1} dividing the line $Q_{n-2} P_n$ in the ratio $m_n : m_1+m_2+m_3+\dots\dots +m_{n-1}$ and with the coordinates

$$\left(\frac{m_1 \log r_1 + m_2 \log r_2 + \dots\dots + m_n \log r_n}{m_1+m_2+\dots\dots+m_n}, \ \frac{m_1 \mathrm{T}(r_1) + m_2 \mathrm{T}(r_2) + \dots\dots + m_n \mathrm{T}(r_n)}{m_1+m_2+m_3+\dots\dots+m_n} \right)$$

i. e.

$$\left(\log \left(r_1^{m_1} r_2^{m_2} \dots\dots\dots r_n^{m_n} \right)^{\frac{1}{M}}, \ \frac{m_1 \mathrm{T}(r_1) + m_2 \mathrm{T}(r_2) + \dots\dots + m_n \mathrm{T}(r_n)}{M} \right)$$

where $M = \sum_1^n m_i$

Using the convexity property we get

$$\frac{m_1 \mathrm{T}(r_1) + m_2 \mathrm{T}(r_2) + \dots\dots + m_n \mathrm{T}(r_n)}{M} \geq \mathrm{T} \left\{ \left(r_1^{m_1} r_2^{m_2} \dots\dots\dots r_n^{m_n} \right)^{1/M} \right\}$$

Now, putting $p_1 = \frac{m_1}{M}$

$$p_2 = \frac{m_2}{M}$$

$$p_n = \frac{m_n}{M}$$

we obtain the inequality proposed, *viz* :

$$\mathrm{T} \left(r_1^{p_1} r_2^{p_2} \dots\dots\dots r_n^{p_n} \right) \leq p_1 \mathrm{T}(r_1) + p_2 \mathrm{T}(r_2) + \dots\dots + p_n \mathrm{T}(r_n)$$

Cor.

$$n.\ \mathrm{T} \left(\frac{n}{\frac{1}{r_1} + \frac{1}{r_2} + \dots\dots \frac{1}{r_n}} \right) \leq n.\ \mathrm{T} \left(\sqrt[n]{r_1 r_2 \dots\dots r_n} \right) \leq \sum_1^n \mathrm{T}(r_i)$$

The right hand side of the inquality can be obtained by putting $m_1 = m_2 = \dots\dots\dots = m_n = 1$, in (3.1). While the other side is obvious because the geometric mean is greater than the harmonic mean of numbers, and since $\mathrm{T}(r)$ is an increasing function of r.

4. Theorm C. Let $w(z)$ be a meromorphic function for which

$$\lim_{r\to\infty} \frac{T(r)}{r} \text{ exists, then}$$

$$\lim_{r\to\infty} \frac{T(r)}{r} = \lim_{r\to\infty} \frac{A(r)}{r}$$

PROOF.

Let $$\lim_{r\to\infty} \frac{T(r)}{r} = \alpha \text{ (say)}$$

then for sufficiently large values of r.

$$r(\alpha-\varepsilon) < T(r) < (\alpha+\varepsilon)r$$

and since [1, p. 177] $T(r) \sim \int_{r_0}^{r} \frac{A(t)}{t}\,dt$

so for $r \geqq r_0(\varepsilon)$ and $k>1$, we have

$$\int_{r}^{kr} \frac{A(t)}{t}\,dt = \int_{r_0}^{kr} \frac{A(t)}{t}\,dt - \int_{r_0}^{r} \frac{A(t)}{t}\,dt$$

$$\int_{r}^{kr} \frac{A(t)}{t}\,dt = T(kr)-T(r)$$

$$< (\alpha+\varepsilon)kr-(\alpha-\varepsilon)r$$
$$= r\{\alpha(k-1)+\varepsilon(k+1)\}$$

But $$\int_{r}^{kr} \frac{A(t)}{t}\,dt \geqslant A(r)\int_{r}^{kr} \frac{dt}{t} > \frac{A(r)(k-1)r}{kr} = \frac{A(r)(k-1)}{k}$$

So $$\frac{A(r)}{r} < \frac{k}{k-1}\{\alpha(k-1)+\varepsilon(k+1)\}$$

Putting $k=1+\sqrt{\varepsilon}$, we get

$$\frac{A(r)}{r} < (1+\sqrt{\varepsilon})\{\alpha+\sqrt{\varepsilon}(2+\sqrt{\varepsilon})\}$$

Hence
$$\overline{\lim_{r\to\infty}} \frac{A(r)}{r} \leq \alpha, \tag{4.1}$$
since ε is arbitrary.

Similarly by considering the integral $\int_{\beta r}^{r} \frac{A(t)}{t}\,dt$ $(\beta<1)$ we can prove, proceeding exactly as above, that

$$\underline{\lim}_{r\to\infty} \frac{A(r)}{r} \geqslant \alpha$$

This togather with the inequality (4.1.) gives the result.

5. Theorem D. The integrals

$$I_1 = \int_{r_0}^{\infty} \frac{T(t)}{t^{m+1}}\,dt$$

and
$$I_2 = \int_{r_0}^{\infty} \frac{A(t)}{t^{m+1}}\, dt$$
converge or diverge together. $(m>0)$

Proof.
$$\int_{r_0}^{r} \frac{A(t)}{t}\, dt = T(r)-T(r_0), \quad r > r_0$$

Hence
$$\int_{r_0}^{u} \frac{dr}{r^{m+1}} \int_{r_0}^{r} \frac{A(t)}{t}\, dt = \int_{r_0}^{u} \left\{ T(r)-T(r_0) \right\} \frac{dr}{r^{m+1}}$$
$$= \left[\frac{T(r)-T(r_0)}{-mr^m}\right]_{r_0}^{u} + \frac{1}{m}\int_{r_0}^{u} \frac{A(r)}{r^{m+1}}\, dr$$
$$= \frac{T(u)-T(r_0)}{-mu^m} + \frac{1}{m}\int_{r_0}^{u} \frac{A(r)}{r^{m+1}}\, dr$$

Also
$$\int_{r_0}^{u} \left\{ T(r)-T(r_0) \right\} \frac{dr}{r^{m+1}} = \int_{r_0}^{u} \frac{T(r)}{r^{m+1}}\, dr - T(r_0) \int_{r_0}^{u} \frac{dr}{r^{m+1}}$$
$$= \int_{r_0}^{u} \frac{T(r)}{r^{m+1}}\, dr + \frac{T(r_0)}{m} \left\{ \frac{1}{u^m} - \frac{1}{r_0^m} \right\}$$

Hence
$$\int_{r_0}^{r} \frac{T(t)}{t^{m+1}}\, dt + \frac{T(r_0)}{m}\left[\frac{1}{r^m} - \frac{1}{r_0^m}\right] = \frac{T(r)-T(r_0)}{-mr^m} + \frac{1}{m}\int_{r_0}^{r} \frac{A(t)}{t^{m+1}}\, dt$$

and so
$$(5.1) \quad m\int_{r_0}^{r} \frac{T(t)}{t^{m+1}}\, dt - \frac{T(r_0)}{r_0^m} + \frac{T(r)}{r^m} = \int_{r_0}^{r} \frac{A(t)}{t^{m+1}}\, dt$$

Let us now suppose that I_1 is convergent, then
$$\varepsilon > \int_{r}^{2r} \frac{T(t)}{t^{m+1}}\, dt > \frac{T(r)}{m\, r^m}\left\{ 1-2^{-m} \right\},$$ for every small $\xi > 0$ consequently, as $r \to \infty$ $\frac{T(r)}{r^m} \to 0$

Hence from (5.1) the convergence of I_2 follows immediately.

On the other hand if I_2 is convergent then, from (5.1) we get
$$(5.2) \quad m\int_{r_0}^{r} \frac{T(t)}{t^{m+1}}\, dt + \frac{T(r)}{r^m} < K$$

and since,

$$\int_{r_0}^{r} \frac{T(t)}{t^{m+1}}dt > T(r_0).\frac{1}{m}\left\{r_\circ^{-m} - r^{-m}\right\} > O$$

both the terms on the left hand side of (5 . 2) are positive and this ensures the convergence of I_1.

From the convergence of I_2 we can also deduce that $T(r) = o(r^m)$. Further we get from (5 . 1) that

$$\int_{r_0}^{r} \frac{A(t)}{t^{m+1}}\, dt > \int_{r_0}^{r} \frac{T(t)}{t^{m+1}}dt$$

Hence the divergence of I_1 implies the divergence of I_2.

Now, let I_2 be divergent. Then I_1 will also be divergent; for if it were convergent, then by the results proved above I_2 will also be convergent which contradicts our hypothesis.

6. Theorem. E. For a meramorphic function $w(z)$

$$(6 . 1) \qquad \lim_{r\to\infty} \begin{Bmatrix}\text{Sup.}\\ \text{Inf.}\end{Bmatrix} \frac{\log\{rT'(r)\}}{\log r} = \begin{matrix}\rho\\ \lambda\end{matrix}$$

($T'(r)$ means $\frac{d}{dr}T(r)$)

PROOF.

$$T(r) = T(r_0) + \int_{r_0}^{r} \frac{A(t)}{t}\, dt, \quad r > r_0$$

so

$$(6 . 2) \qquad T'(r) = \frac{A(r)}{r} \text{ except for a set of measure zero.}$$

Hence

$$\lim_{r\to\infty} \begin{Bmatrix}\text{Sup.}\\ \text{Inf.}\end{Bmatrix} \frac{\log\{r\,T'(r)\}}{\log r} = \lim_{r\to\infty} \begin{Bmatrix}\text{Sup.}\\ \text{Inf.}\end{Bmatrix} \frac{\log A(r)}{\log r}$$

and the result follows from (1 . 2).

Theorem F. For a meromorphic function $w(z)$

$$(6 . 3) \qquad \lambda - \rho \leq \varliminf_{r\to\infty} \frac{\log\left\{\frac{r\,T'(r)}{T(r)}\right\}}{\log r} \leqslant 0 \leqslant \varlimsup_{r\to\infty} \frac{\log\left\{\frac{r\,T'(r)}{T(r)}\right\}}{\log r} \leqslant \rho - \lambda$$

Proof. From (6 . 2) we get for $r > r_0$

$$(6 . 4) \qquad r\,\frac{T'(r)}{T(r)} = \frac{A(r)}{T(r)}$$

except for a set of measure zero.

Hence

$$\varlimsup_{r\to\infty} \frac{\log\left\{\frac{r\,T'(r)}{T(r)}\right\}}{\log r} = \varlimsup_{r\to\infty}\left\{\frac{\log A(r)}{\log r} - \frac{\log T(r)}{\log r}\right\}$$

$$\geqslant 0$$
$$\leqslant \rho - \lambda$$

Also from (6 . 4) we have

$$\underline{\lim}_{r \to \infty} \frac{\log \left\{ \dfrac{r\,\mathrm{T}'(r)}{\mathrm{T}(r)} \right\}}{\log r} = \underline{\lim}_{r \to \infty} \left\{ \frac{\log \mathrm{A}(r)}{\log r} - \frac{\log \mathrm{T}(r)}{\log r} \right\}$$
$$\leqslant 0$$
$$\geqslant \lambda - \rho$$

This proves the theorem.

7. **Applications.** From (6 . 1) and (6 . 3) we very easily deduce the following results :

(7 . 1)
$$\overline{\lim}_{r \to \infty} \frac{\log \mathrm{A}(r)}{\log r} = \rho = 1 + \overline{\lim}_{r \to \infty} \frac{\log \mathrm{T}'(r)}{\log r}$$

(7 . 2)
$$\underline{\lim}_{r \to \infty} \frac{\log \mathrm{A}(r)}{\log r} = \lambda = 1 + \underline{\lim}_{r \to \infty} \frac{\log \mathrm{T}'(r)}{\log r}$$

and

$$\lambda - \rho - 1 \leqslant \underline{\lim}_{r \to \infty} \frac{\log \left\{ \dfrac{\mathrm{T}'(r)}{\mathrm{T}(r)} \right\}}{\log r} \leqslant \overline{\lim}_{r - \infty} \frac{\log \left\{ \dfrac{\mathrm{T}'(r)}{\mathrm{T}(r)} \right\}}{\log r} \leqslant \rho - \lambda - 1$$

REFERENCES

1. Nevanlinna, R., Eindeutige Analytische Functionen Springer Verlag (1955).